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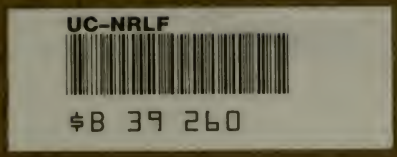


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# SOME ASPECTS

OF

# METROPOLITAN ROAD AND RAIL TRANSIT.

## LECTURE

BY

HENRY HERMAN GORDON, B.A., Assoc. M. Inst. C.E.

WITH A REPORT OF THE DISCUSSION.

LONDON:
Published by The Institution
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# THE INSTITUTION OF CIVIL ENGINEERS.

25 November, 1919.

Sir JOHN PURSER GRIFFITH, President,
in the Chair.

## LECTURE

ON

## "Some Aspects of Metropolitan Road and Rail Transit."

By HENRY HERMAN GORDON, B.A., Assoc. M. Inst. C.E.

### INTRODUCTORY.

POPULARIZATION of electric traction and development of self-propelled vehicles have led in all parts of the country to a greater demand and utilization of traffic facilities. More particularly in large urban centres, it cannot be said, however, that any simplification in the problem connected with transit, the co-ordination of traffic or constructional applications has been thereby effected. In so far as movement on the highway is concerned, difficulties have been accentuated. Vehicles of yet more varying sizes, weights and speeds are placed on roads of equally varying dimensions and construction. There has been little premeditated effort to fit either the vehicles to the roads or the roads to the vehicles they are to accommodate.

Although during the latter years of the war the application of mechanical traction to goods-carrying vehicles has advanced rapidly, it still lags far behind the position existing in the case of passenger vehicles, the motorization of which in the Metropolis may be said to have been nearly completed. The character of traffic in three typical London streets is shown in the following Table. In the first and second, passenger and goods vehicles respectively predominate. In the third there is a nearer approach to equality.

The number of vehicles in the principal streets—but not their carrying capacity—has shown in recent years some slight diminution Even where motor traffic largely predominates there has been no real decrease in road congestion, and in the central area of London it is



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TABLE I.—POSITION AS TO MOTORIZATION, 1914.[1]

| | Passenger Vehicles. | | | | Goods Vehicles. | | | |
|---|---|---|---|---|---|---|---|---|
| | Motor-driven. | Horse-driven. | Total. | Per-centage of Motor to Total. | Motor-driven. | Horse-driven. | Total. | Per-centage of Motor to Total. |
| Oxford Street, West of Oxford Circus . . . | 9,675 | 241 | 9,916 | 97·7 | 416 | 2,876 | 3,292 | 12·6 |
| Tower Bridge . | 686 | 61 | 747 | 91·8 | 323 | 9,674 | 9,997 | 3·2 |
| Whitechapel, High Street . | 4,783 | 155 | 4,938 | 97·0 | 505 | 5,618 | 6,123 | 8·2 |

found uneconomical to employ motor delivery vans. The carrying capacity of the highway has been and remains taxed to the uttermost.

In the communal interest it would be wrong to hope for any retardation in the growth of traffic demand. To relieve surface congestion it is frequently suggested that further passenger transit facilities should be provided underground. Apart from financial considerations, experience in all parts of the world has shown that the remedy is illusory. In 1895, before the Central London Railway was opened, 390 horse omnibuses passed along sections of Oxford Street each hour. In 1903, there was a temporary reduction of 60 vehicles. In 1913, at periods of the day when the Central London Railway is packed to repletion, 517 motor omnibuses with 70 per cent. more accommodation in total than in 1895, were unable to cope with the demand made upon them. In Paris, shopkeepers of the Rue de Rivoli protested against the original construction of the Metropolitaine, fearing the streets would be deserted. The "Metro" has been doubled; a constant succession of motor omnibuses traverses the streets; an improved tramway system has been installed; Paris streets are more crowded than ever. In 1914, in Budapest a single horse omnibus running immediately above, still competed successfully with the first electric shallow subway constructed in any part of the world. The experience of New York, Chicago, Berlin, Hamburg, is the same. Sub-surface facilities do

[1] At midsummer of the current year out of 17,590 passenger-carrying vehicles passing at five typical points in 12 hours, only 360, or 2 per cent., were horse-driven. Of 23,902 goods-carrying vehicles at the same points, 18,330, or over 76 per cent., were horse-driven.

not reduce the volume of surface traffic. The two serve different purposes and surface traction always grows more rapidly than any underground system. In the decade ending in 1913, underground traffic in London increased by 170,000,000 passengers; surface traction by 870,000,000. Congestion on the highway will continue to be a problem unless the solution to it be found on the surface of the streets.

Unfortunately the factors which lead to increase in surface traffic render the solution by the mechanical process of street widenings more expensive. The cost of improving the Strand is at the rate of over £5,000,000 per mile. Before expenditure of this character is undertaken, it is of primary importance that every square foot of existing accommodation should be utilized to its maximum advantage. This is far from being actually achieved.

Many of the methods for improving the carrying capacity of the highway call for no constructional work on the part of the engineer. They do demand, however, a more stringent code of traffic regulation such as exists—but is inadequately enforced—in many foreign cities. Frontagers in London utilize streets widened at enormous cost for standing vehicles. Road repairs are leisurely carried out irrespective of the loss occasioned. Vehicles of especially obstructive character wander almost at will through important streets. Scavenging the highway is frequently done when considerable traffic has developed. Better regulations to deal with such abuses will be of temporary service. Owing to the steady growth of traffic, these remedial measures will become exhausted and ultimately street widenings or alternative routes must be provided. Under all circumstances it will be increasingly the function of the engineer to relate the design and construction of roads and vehicles more to one another.

Only a superficial examination of the problem could lead to the conclusion that road and rail traffic are mutually exclusive. This is quite apart from the question of the part played by surface and underground traction in supplying traffic needs in large urban centres. The transit demands made by a community are infinite in their complexity. They relate to persons and goods, in bulk and detail. They differ in direction, frequency, time allowable for their accomplishment. There is no patent nostrum which will meet all traffic demands and cure all traffic ills. The object of this lecture is to refer to phases of the problem less commonly dealt with, to investigate some of the characteristics of Metropolitan traffic, and to examine the capacity of the means employed in local transit.

## PART I.—ROADS AND VEHICLES.

### The Maximum Capacity of Highways.

Movement of vehicles necessarily entails for a period of time occupation of highway surface. Time of occupation is determined by velocity of motion; quantity of occupation by size of vehicles. By "size of vehicles" must be understood not merely actual physical dimensions. In order that vehicles going at varying speeds in the same direction, or at any speed in opposite directions, may be able to pass each other without arrest of motion, it is essential a safety margin must be allowed over and above the actual width. Similarly an interval must be preserved between following vehicles in the same track so that in the event of the forward vehicle for any reason suddenly stopping, the rear vehicle can draw up without risk of accident. The dimensions of a vehicle increased for the foregoing reasons may be termed its "virtual width" or "virtual length."

The directions highways take are determined by a multitude of economic, physical and even historic considerations which the engineer is bound to accept. The width generally is more under his control. Roads should be designed as multiples of virtual widths rather than with the intention of making them an even number of feet. With a roadway designed on this basis, the total carrying capacity will be directly proportional to the number of tracks and the velocity in each. Obviously the course of every vehicle at any one time should be strictly confined to its own track.

On any given track fully utilized, the speed of transit will be determined by its slowest moving vehicle. Sharp curves and heavy grades which reduce speed will reduce capacity. From these considerations it appears that the maximum carrying capacity of a multiple track highway will be reached when vehicles follow in straight lines, and in each line with uniform assigned speed.

In practice the virtual widths of vehicles is but little affected by variation of speed. The virtual length, however, which includes the stopping distance, is obviously a function of the speed of transit. It is of interest, therefore, to examine what relationship exists between the maximum carrying capacity of a highway, the speed of transit, and the actual and virtual length of vehicles.

Let L be the actual length of the vehicle.

V be the speed of transit in feet per second.

S be the stopping distance at a speed V.

M be the total mass of vehicle and load.

$f$ be the retarding force due to brake action, friction, etc.

The total retarding force is M $g f$. The work done in arresting the vehicle, $MV^2$ is equal to 2 M $g f$ S.

Eliminating M and writing F for $g f$,

$$V^2 = 2 F S \text{ or } S = V^2/2 F.$$

The virtual length of the vehicle is therefore $L + V^2/2 F$

The time taken to traverse this distance is $\frac{L + V^2/2 F}{V}$

The condition for maximum carrying capacity obviously entails that this quantity should have a minimum value. This condition is fulfilled when $V^2$ equals 2 F L.

With these conditions, the occupation of the highway will be limited to 2 L/V seconds and the maximum number of vehicles which the track will accommodate is therefore V/2 L. In other words, the maximum track capacity for a given type of vehicle is attained when the velocity is such that the virtual length of the vehicle is twice the actual length.

This deduction is capable of easy practical verification. Table II gives the emergency and service stop prevailing on the London County Council Tramway system. To these figures have been added the number of cars which can pass a given point in one minute.

Table II.—Virtual Lengths of Tramcars and Road Capacity.

| Speed in Miles per Hour. | Virtual Lengths with | | Cars per Minute with | |
|---|---|---|---|---|
| | Emergency Stop. | Service Stop. | Emergency Stop. | Service Stop. |
| | Feet. | Feet. | | |
| 2 | 37·0 | 38·0 | 4·8 | 4·6 |
| 4 | 37·3 | 39·7 | 9·4 | 8·9 |
| 6 | 40·4 | 46·8 | 13·0 | 11·3 |
| 8 | 45·3 | 55·5 | 15·5 | 12·7 |
| 10 | 50·4 | 64·0 | 17·5 | 13·8 |
| 12 | 57·5 | 78·0 | 18·4 | 13·5 |
| 14 | 66·0 | 94·0 | 18·7 | 13·1 |
| 16 | 76·0 | 112·0 | 18 5 | 12·6 |
| 18 | 87·0 | 129·0 | 18·2 | 12·3 |

The tramcar is 34 feet actual length.

The maximum number of cars which can be run with the emergency and service stops is at 14 and 10 miles per hour respectively. In both cases the virtual length is twice the actual length. The Table also shows that, with due regard to the conditions of safe working, a relatively high speed may reduce the carrying capacity of a track as much as a relatively low speed. Taking as an illustration the emergency stop, at 10 miles per hour nearly as many cars can pass as at 18. From the point of view of road occupation or road obstruction there is an economic limit of speed for varying types of vehicles, and if speed limits are imposed they should be applied at both ends of the scale.

It has been assumed in the preceding investigation that no obstruction is caused by cross traffic or standing vehicles. These assumptions are most nearly realized in London in the bridges spanning the river. London Bridge has a carriage way of 37 feet, providing for four lines of traffic. Proportionally to width, it carries the largest number of vehicles and more particularly at "rush hours" seems hopelessly congested. It is indicative of the growth of London traffic that the Tower Bridge, built a generation ago to relieve the pressure, has become itself exceedingly congested without, however, accomplishing its original purpose to any material extent.

The virtual lengths of vehicles using the slow and fast tracks on London Bridge at 4 and 8 miles respectively per hour, may be averaged at 30 and 40 feet. The corresponding capacity for each track is therefore 704 and 1,056 vehicles per hour, or a total of 42,240 vehicles in the twelve hours during which traffic is usually enumerated. On a typical day—Thursday, July 16th, 1914, from 8 a.m. to 8 p.m.—15,068 vehicles, exclusive of 2,160 cycles and 1,149 barrows, traversed the bridge which at all times seemed hopelessly congested. Excluding cycles, this is only 38 per cent. of the rated capacity. Traffic varies, however, both in intensity and direction at different hours of the day. The maximum intensity was in the direction of the city between 4 p.m. and 5 p.m. The composition of this traffic is shown in Table III.

In this hour, 721 vehicles crossed the bridge, an efficiency of 41 per cent. The vehicles described as "fast" and "slow" were 588 and 133 respectively. Even if travelling in their appropriate tracks, only 56 per cent. of the "fast" and 19 per cent. of the "slow" was utilized. It may be asked therefore why is London Bridge so congested?

Watching the course of traffic shows why results fall so far short of theoretic conclusions. The assumption that vehicles follow each other in regular lines with uniform but graduated speed in each are

TABLE III.—MAXIMUM TRAFFIC ON LONDON BRIDGE.

| Description. | Horsed Vehicles. | | | Description. | Motor Vehicles. | | |
|---|---|---|---|---|---|---|---|
| | Fast. | Slow. | Total. | | Fast. | Slow. | Total. |
| *Trade.* | | | | *Trade.* | | | |
| One Horse . | 159 | 85 | 244 | Light . . | 7 | .. | 7 |
| Two Horse . | 30 | 44 | 74 | Heavy . . | 15 | 4 | 19 |
| *Passenger.* | | | | *Passenger.* | | | |
| Cabs . . . | 10 | .. | 10 | Cabs . . . | 144 | .. | 144 |
| | | | | Carriages . . | 30 | .. | 30 |
| Carriages . . | 10 | .. | 10 | Omnibuses . | 183 | .. | 183 |
| | 209 | 129 | 338 | | 379 | 4 | 383 |

far from being realized. Lumbering vehicles encroach on tracks reserved for fast traffic. For all kinds of inadequate reasons vehicles stop and cause congestion. The part flexibility of traction plays in accentuating traffic delays will be examined hereafter. London traffic rarely proceeds in regular flow; most frequently only in irregular spasms.

To the traffic formula, "Keep to the Left" should be added the equally important injunction, "Keep in Line." If some easy method of marking the track longitudinally could be devised, and needless encroachment on more than one were made a breach of traffic regulations, a material increase in the carrying capacity of the existing highways would ensue.

## STREET CROSSINGS.

The street plan of large urban centres generally entails that non-parallel arterial roads shall intersect in the same horizontal plane. An area common to the converging streets is formed which all through traffic is bound to traverse. Where roads having a width of A and B feet respectively meet at an angle C, the crossing area serving both is equal to AB cosec C.

The longer the time taken to cross, the greater the interference with the traffic flow in one street or the other. The crossing length should therefore be as short as possible. The minimum value for AB cosec C is when C is 90°. In other words, street crossings should be rectangular.

It is suggested by those interested in town planning largely from the aesthetic point of view, that this conclusion is erroneous. It is said that the design shown in *Fig. 2* is superior to *Fig. 1* while *Fig. 3* is superior to both. These conclusions are supported by calculations as to the number of possible "collision points" on the not very profitable assumption that all converging traffic simultaneously uses the crossing.

From a traffic point of view the design in *Fig. 2* could be scarcely worsened. The whole of the through and crossing traffic passes through the bottle-neck in the centre, and, splitting up the points of divergence, will cause a further reduction of speed on a

*Fig. 1.*

Ordinary Rectangular Crossing indicating Tracks and possible "Collision" Points.

length where rapid clearance is of the utmost importance. The design is stated to have the architectural advantage of providing "closed vistas. As highways are primarily required for the utilitarian purpose of accommodating traffic, considerations which so completely militate against efficiency can claim only secondary place.

*Fig. 3* shows an undoubted improvement of *Fig. 2*, and a scheme on these lines has been carried out at the Marble Arch with benefit to traffic. It is interesting to note what is the cause for this improvement. By the creation of the lower parallel street, the street corresponding to Park Lane on the plan has been carried westward (independent of the through street, Oxford Street and

Bayswater Road) until its centre line coincides with Edgware

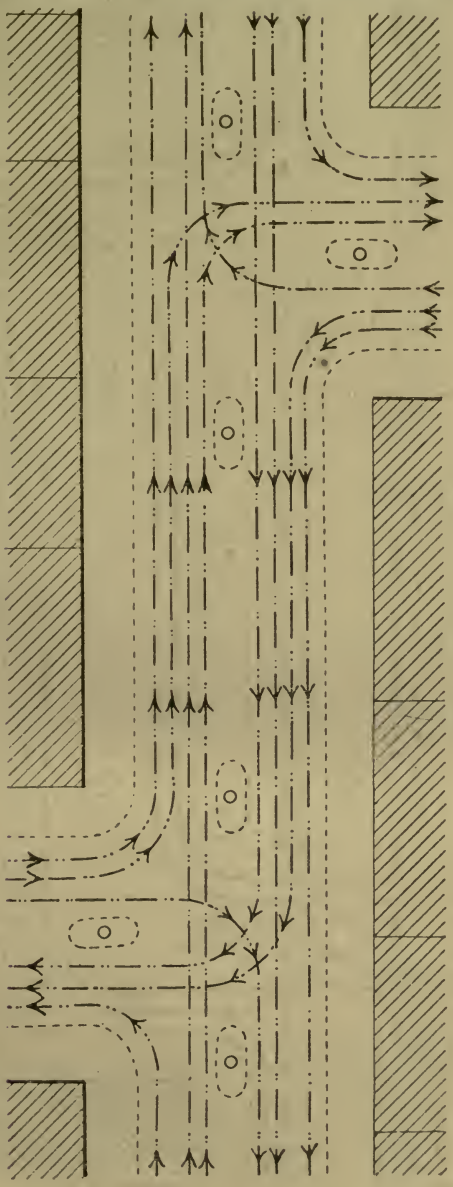


*Fig. 2.*

Split Rectangular Crossing.

Road. The original crossing, which was of the type shown in

*Fig. 2*, has been made more nearly rectangular, and the benefit

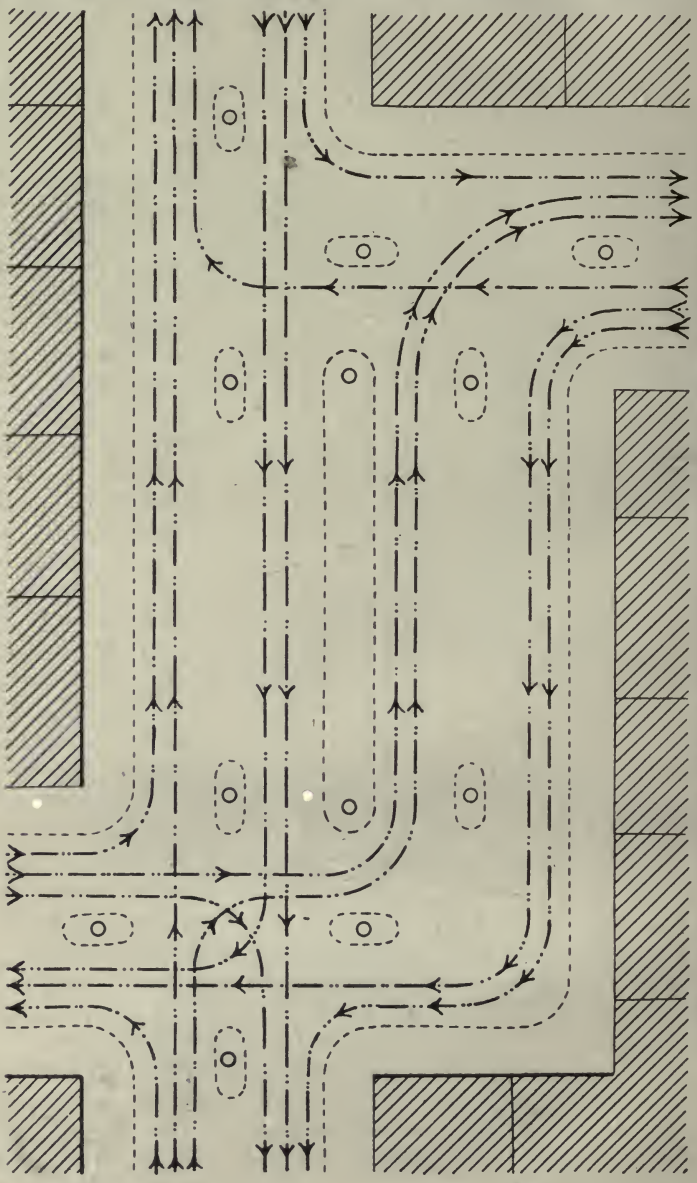


*Fig. 3.*

Scheme of the Crossing at Marble Arch after Conversion from the Type shown in *Fig. 2.*

which has accrued is strong confirmation of the plea for rectangular

crossing areas. The inconvenience of acute angled crossings such as exists in front of the Mansion House station on the District Railway (Cannon Street and Queen Victoria Street), leads to similar conclusions.

The time lost by the intervention of crossings is not limited merely to the period during which no locomotion at all takes place. Vehicles have to come to rest and start from rest. Facilities for acceleration and deceleration are therefore of great importance. In these respects motor traction has been of the greatest service in crowded thoroughfares in Central London.

Traffic in the City proceeds at scarcely a higher rate of speed than before the introduction of motor traction. The effect of increased traffic is cumulative at traffic crossings. In 1902 the Royal Commission on London Traffic urged the necessity for a subway in Piccadilly where the east and west traffic is cut by the north and south traffic in St. James's Street. In 1902 there were 15,000 vehicles proceeding east and west in 12 hours: in 1914 there were 25,000. North and south traffic had increased in similar proportions. If the original conditions had continued to exist traffic would long ago have been blocked. In 1902 all traffic was animal driven; in 1914, 83 per cent. was power driven. Power of rapid acceleration and deceleration has reduced the crossing time and provided greater capacity. This feature has saved the situation.

The joint carrying capacity of two converging streets is reduced to less than either by the intervention of crossings. It needs no argument therefore that wherever gradients permit, important thoroughfares should cross by viaducts or subways.

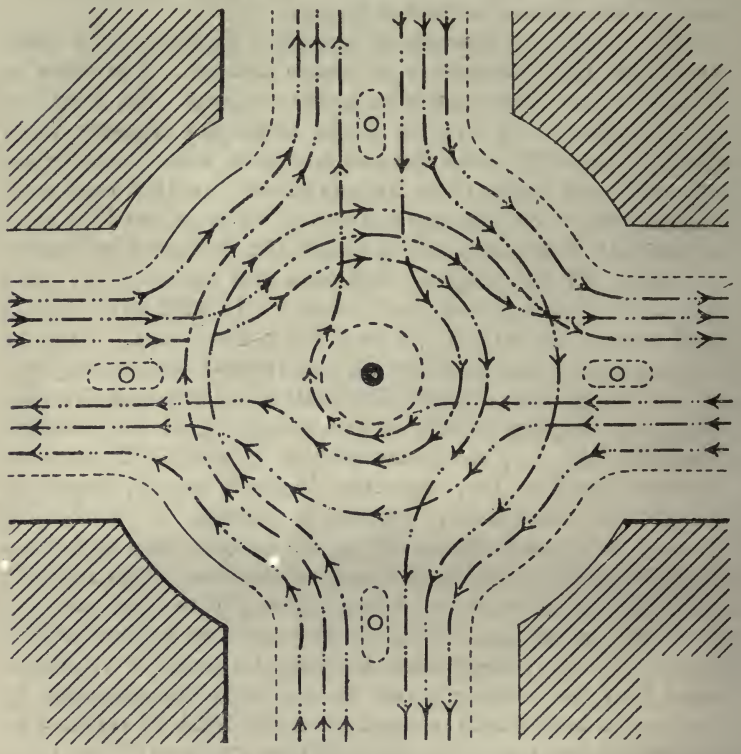
It may be objected that owing to the irregular flow of traffic a crossing frequently holds up no vehicles whatever. This no doubt is true. On every important urban highway there are, however, periods of time when a continuous procession of vehicles utilizes the street. It is precisely when the largest number of vehicles is affected that the crossing entails its maximum disadvantage. It is no answer to the daily congestion at the Bank to say that at night time there is no obstruction. There are few vehicles to be obstructed.

These considerations lend importance to the inquiry whether by improved methods of traffic regulations difficulties could be minimized. The "gyratory" system is alleged to achieve this result. All vehicles pursue circular tracks to the left or right, according to the prevailing rule of the road, until they reach their points of emergence (*Fig. 4.*). The continuous alternate pauses observed under the system in the Metropolis certainly disappear.

On analysis it will appear, however, that these periods are simply broken up into a number of short pauses, which in the aggregate cannot involve less loss of time and may involve even more.

In *Fig. 4* two streets converge forming a crossing worked on the gyratory system, all vehicles proceeding to the left. The streets are assumed to be fully loaded, and the traffic is supposed to distribute itself equally into the three remaining directions.

*Fig. 4.*

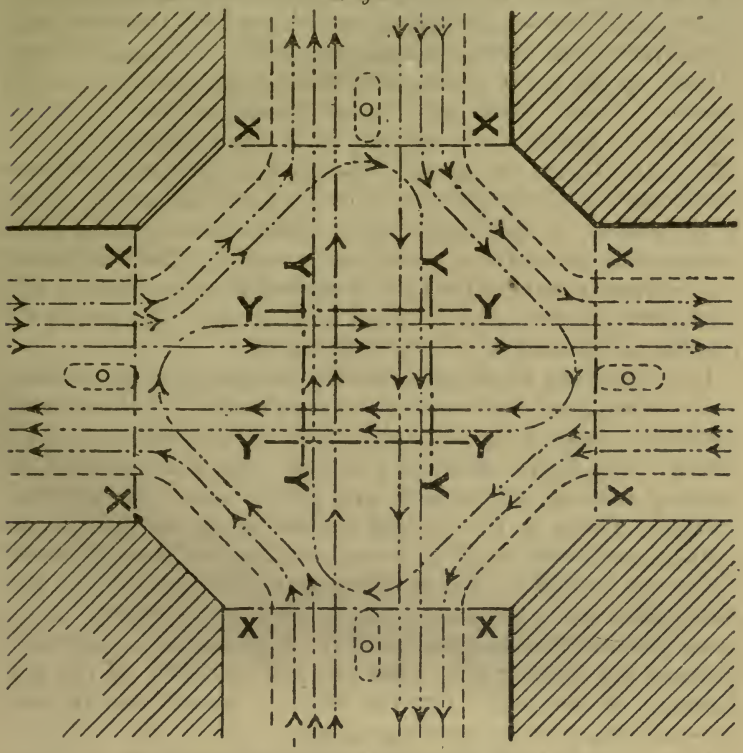


Left-handed "Gyratory" Crossing.

The tracks which must be followed are indicated. Under the gyratory system twice as many tracks are provided in each quarter as in any one of the converging streets. Traffic diverging to the left, if nearest to the kerb, can flow continuously, but this is also possible with an ordinary rectangular crossing. Traffic desirous of continuing in the straight or of diverging to the right must hold up or be held up when crossing the other streams. No traffic regulation can overcome the physical fact that where vehicles cross

on the level only one can be at one place at one time. To attain under the gyratory system even the capacity of the Metropolitan

*Fig. 5.*




PROPOSED MODIFIED RECTANGULAR CROSSING.

METHOD OF WORKING.

(1) *In a multiple-track highway, all vehicles diverging from the straight take the track or tracks nearest to the kerb on approaching the crossing.*

(2) *If the crossing be open for north and south traffic, all east and west vehicles draw up at the lines XX, XX.*

(3) *North and south traffic continuing along the straight or diverging to the left proceeds unhindered.*

(4) *North and south traffic diverging to the right follows the track indicated and halts in the space between the lines XX, YY. It is now in the appropriate position to use the crossing when this is opened for east and west traffic.*

*The effective crossing area enclosed by the four lines YY is always free from standing vehicles, and can always be used in both directions.*

system implies a synchronization of the motion of vehicles almost impossible of realization.

In one respect, however, the enlarged area offers great advantages. If traffic on a rectangular crossing diverges to the right, its effect is most prejudicial. Having traversed half the crossing area it has to cut the line of traffic proceeding in a parallel but contrary direction to its original course. Diverging traffic is generally relatively small as it involves two sides of a triangle. While diverging, however, it holds up the larger stream, and unless ample standing room be provided, it may block traffic in all directions. For vehicles to stand in the centre of a crossing area is the last thing to be contemplated. Under the gyratory system, it is immaterial whether traffic proceeds to the right or continues in a straight course. There is an absence of that appearance of delay and confusion which characterises the ordinary rectangular crossing. The existence of the divergent stream to the right is equivalent to the creation of a third traffic stream using the same crossing area. Necessarily the resultant delay must be materially increased.

It is important therefore to examine whether by some modification of design and traffic regulation the simplicity of the ordinary rectangular crossing can be retained despite diverging traffic. The design in *Fig. 5* gives effect to this idea. The four corners of the ordinary crossing are recessed and provide space for gathering grounds. Traffic on the straight proceeds along one street in the ordinary way, while traffic in the street at right angles to it is held up at the lines XX. Traffic diverging to the right in the first street takes the track nearest to the kerb and draws up in the space between the lines XX and YY. It is now in a position to traverse the crossing area when the flow of traffic in the new direction is resumed. But the effective central crossing area remains always clear of standing vehicles.

In a multiple track highway, regulations should prescribe that all diverging traffic should take the track nearest to the kerb.

With this simple modification in design and regulation the influence of diverging traffic will be minimized, and the advantages of the ordinary rectangular crossing will be retained.

## Capacity and Flexibility of Traction.

The time of road surface occupation by any vehicle is determined by the speed of transit and the virtual length of the vehicle at that speed. During this time the highway may be said to be denied to all others and, in a not altogether felicitous phrase, to be "obstructed." The "Factors of Obstruction" have been extensively studied in the annual reports of the Traffic Branch of the Board of Trade from

1910 onwards. They are based on size, speed, flexibility and empyric deductions. Originally enunciated in 1910, they have been modified in later issues. The factors now utilized are recorded in Table IV, the figures in brackets being the original assigned values.

TABLE IV.—FACTORS OF "OBSTRUCTION."

| Trade Vehicles. | | | Passenger Vehicles. | | |
|---|---|---|---|---|---|
| Description. | Fast. | Slow. | Description. | Horse. | Motor. |
| One horse . . . | 3 | 7 | Electric tram . . | .. | 9 (10) |
| Two horse . . . | 4 | 10 | | | |
| Light motor . . | 1 | .. | Omnibus . . . | 5 | 4 (3) |
| Heavy motor . . | 3 | 5 | Cabs . . . . | 2 | 1 |
| Barrows . . . | .. | 4 | | | |
| Cycles . . . . | ½ | .. | Carriages . . . | 2 | 1 |

These factors are open to criticism. Every morning at rush hours a hundred tramcars with 9,000 passengers approach the Victoria terminus. According to the Table, they caused in arriving and departing 1,800 units of road obstruction. To provide the same capacity, 230 motor omnibuses would be required, which in arriving and departing would cause 1,840 units of road obstruction, a result quite opposite to that the Table indicates. It is difficult to see why vehicles equally described as "slow" should have different factors according to whether they are drawn by one or two horses. The number of horses is determined more by the load than size of vehicle. It is not easily intelligible why a tramcar and motor omnibus, which at their normal speed can both draw up within their own length and therefore fulfil the conditions for economic user of road surface, should have such vastly varying factors. To allege that a horse omnibus is as obstructive as a heavy slow moving motor is difficult to believe. The determination of road occupation, previously given, is based on two of the factors, speed and size, on which Table IV is formulated. It necessarily ignores empyric deductions and flexibility, to the last of which so much importance is attached by those responsible for its compilation. It is desirable therefore to see whether this importance is intrinsically deserved.

The term "flexibility" is commonly used in two senses. In the first it denotes that a certain vehicle is not tied to a given route, but may, without further adaptation, select any other route. In the second sense it implies that when on a given route it can readily

change its position of sequence in any traffic file. In the first sense, flexibility is of primary importance in determining the work the vehicle can perform. If the route to be followed is constantly varied, it is essential that a vehicle not tied to rails be employed. From the point of view of road obstruction this consideration must be ignored. The power that on another day a vehicle may be on another route does not diminish the road occupation it entails at the given moment. The only flexibility which can be assumed to affect the factors of obstruction must be that in the second sense, the power to change sequence in a traffic line.

The most flexible vehicle pursues a straight course in the absence of obstruction. Flexibility is only brought into use to avoid obstacles. The utmost that can be claimed is that it is a palliative, not a cure. Attention should primarily be devoted to the removal of the many easily preventible obstacles rather than the mere increase in flexibility.

As a palliative its efficiency is strictly limited. Where the road is free from congestion, it is most easily applied and least wanted. Where traffic is most dense, its capacity for being used is least and accompanied by the greatest amount of public danger. A motor omnibus is intrinsically not less flexible when running between Liverpool Street and Ludgate Hill than when running on the Great Western Road to Slough. In the latter case it may run at 18 miles per hour in a dead straight line without flexibility. In the former, with it, its speed frequently drops below 4 miles per hour.

A close parallelism exists between the factors of obstruction given above and the number of accidents on the public highway associated with each type of vehicle. It is not a little remarkable that the record of the Metropolitan Police shows a larger number of accidents in connection with cycles, the obstruction factor of which is least, than with any other type of vehicle. In 1918 tramcars with a factor of nine were associated with 2·8 fatalities per 100 cars in average use; motor omnibuses with a factor of 4 were associated with 6·75 fatalities per 100 omnibuses in average use. The method of stating accidents per hundred vehicles employed places the omnibuses in a more favourable position than is intrinsically deserved.

In evidence given before the Select Committee on Motor Traffic, 1913, the police authorities analysed fatalities in London streets under varying traffic conditions. Those associated with tramways and omnibuses are recorded in Table V.

TABLE V.—ACCIDENTS AND FLEXIBILITY.

| Character of Traffic. | Tramway Fatalities. Tramcar Factor 9. | Omnibus Fatalities. Omnibus Factor 4. |
|---|---|---|
| 1. Very congested. . . . . | 10 | 103 |
| 2. Congested . . . . . | 23 | 136 |
| 3. Considerable . . . . . | 39 | 113 |
| 4. Medium. . . . . | 10 | 10 |
| 5. Light . . . . . | 5 | 2 |

As the precise number of vehicles in each class is not ascertainable, only general conclusions can be drawn. Tramways are largely excluded from streets described as "very congested." It would not be fair, therefore, to institute comparisons in this sub-division. As traffic becomes lighter, that is where flexibility is less necessary and therefore less used, the disparity between the relative safety of tramcars and omnibuses becomes less and less. Indeed, when traffic conditions are such that congestion can not be said to have influence, accidents seem independent of the character of the vehicle, whether railbound or not.

No standard form exists in which accident records in connection with traffic are presented. Not infrequently they are stated in terms of "vehicles employed" or "mileage run." Accidents may be regarded as part of the cost incidental to transport, and should be related to the useful work done. They should, therefore, be stated in terms of so many passengers or tons of goods carried. To state them in any other way is misleading. The primary object of vehicles is transport. If to give a certain output of transport renders it necessary to employ a different number of vehicles or to run a greater or lesser number of miles, accompanied with a greater or lesser number of accidents, the only constant factor is the transport work actually accomplished, and it is to this standard that accidents must be related.

To this point, flexibility has been considered mainly in its relationship to the vehicle itself. It must now be considered in regard to its effect on other traffic and street congestion. In a busy street where the flow of traffic is equal in both directions, flexibility frequently enables a vehicle to pass slower traffic by encroaching on tracks reserved for traffic in the reverse direction. This encroach-

ment, however, is at the expense of reducing the speed of other vehicles, the track of which is impinged.

The prejudicial effect of flexibility can, however, be most clearly seen when examining traffic movement in the neighbourhood of a popular omnibus stopping place such as exists at Marble Arch. Near this point, the motor omnibuses diverge from the fast traffic line to load and unload at the curb. The curb track is largely utilized by heavy railway vans proceeding to Paddington. Owing to the standing omnibuses, this traffic takes the fast track, thus reducing the speed of all motor traffic, other than omnibus, which uses Oxford Street. When the motor omnibuses by the curb have finished loading and unloading, they revert to the fast traffic line, and slow moving traffic resumes its original track. As this slow moving traffic is practically entirely horse traffic, with limited powers of acceleration, stopping or diverting it to the fast traffic line causes more congestion than if power-driven vehicles had their motion arrested. It was recognition of this aspect of flexibility which caused the Traffic Branch of the Board of Trade to reduce the factor of obstruction of tramcars from ten to nine and to increase the factor of motor omnibuses from three to four. This emphasizes the conclusion drawn by the Advisory Board of Engineers of the Royal Commission on London Traffic, which consisted of Sir John Wolfe-Barry, Sir Benjamin Baker, Past-Presidents Inst. C.E.; and Mr. W. Barclay Parsons, M. Inst. C.E., Chief Engineer to the New York Rapid Transit Commissioners:—

> "It is argued in favour of omnibuses that being fixed to no special part of the road, their elasticity of movement aids them in threading their way; but on the other hand, this very elasticity which permits omnibuses to turn out from stopping places out of their proper order and to meander and move sideways on the road and to be driven two or more abreast, is in many cases a material element in road congestion."

It is submitted therefore that the assignment of positive value to flexibility in determining factors of road obstruction is not justified by theoretic consideration or practical experience. Most of the advantages claimed for it could be better achieved by more stringent traffic regulation.

In this connection the proper location of refuges in the street is of importance. At present they divide traffic in direction only. There is increasing tendency in Paris and other continental cities to place refuges so as to graduate traffic according to speed, and

motor omnibuses stop in their appropriate track at elongated refuges placed between the slow and fast tracks.

Of more practical value than mere "coefficients of obstruction" are what may be termed "co-efficients of utility," that is, the amount of road obstruction in relation to useful work done. Thus a tramcar at 10 miles per hour, with a virtual length of 64 feet, carrying seventy-eight passengers, may be said to have a factor of nearly 18. A motor omnibus, at the same speed, with a virtual length of 46 feet, carrying thirty-four passengers has a factor nearly 11. The same principles can be applied to the carriage of goods. They form a better index of the relationship existing between roads and vehicles than factors of obstruction.

The importance of these coefficients must not be misunderstood. They form only one consideration in the determination of the choice of any type of vehicle for a given transport purpose. There are other determinants of not less importance. There are questions of capital cost and working charges; total volume; fixity or diversity in direction; uniformity or variability in intensity of user. All these have their bearing and the right choice of instrument, while enormously influenced by such data as to constructional and working costs, which the engineer must supply, must nevertheless in the end be largely determined by the accumulated traffic experience of the expert traffic manager.

## PART II.—TRANSPORT.

### Metropolitan Passenger Traffic.

In consequence of the war, the passenger transportation facilities existing in Greater London to-day differ only in the very slightest degree from those prevalent at the end of 1913. Figures relating to that year may therefore be taken as applicable to-day. This applies only, however, to those features which are more or less permanent. Operating costs have changed enormously, and what future construction costs may be can at present only be regarded as indefinite. Under these conditions, it has been thought best to state capital costs as at the end of 1913, and to give operating costs both for that year and for 1918.

*Railways.*—At the end of 1913 the length of passenger railways in Greater London amounted to nearly 670 miles with 628 passenger stations. Of this quantity, 545 miles and 424 stations were in connection with main lines and suburban branches of the

nine great trunk railways serving the Metropolis. No figures are available to show the numbers carried. A census for October 1911 indicated that the volume of traffic carried within a 15 mile ring amounted to about 33 per cent. of the total passengers carried by the trunk railway system. On this assumption, in 1913 the number of passengers approximated to 300 millions or 580,000 passengers per mile of route. Less than 5 per cent. of the track was equipped for electric traction. Stations on the average are $1\frac{1}{4}$ miles apart.

At terminal stations of these lines on an ordinary weekday in December, 1913, 2,890 trains arrived. The seating capacity of the trains arriving between 8 a.m. and 9 a.m. varied from 400 to 700, these last being the rush hour trains on the Great Eastern Railway.

Apart from trunk railways, there were 124 route miles nearly all equipped for electric traction. The length of local lines of standard construction was 82 miles; of deep level tubes, 42 miles. On the former, there were 115 stations, spaced $\frac{3}{4}$ mile apart; on the latter, 89 stations at $\frac{1}{2}$ mile intervals. The number of passengers per mile of route on local lines was 3,600,000 per annum; on tube railways 4,250,000 passengers per annum.

At terminal stations of standard local lines, 2,242 trains arrived in the day, the seating capacity at the rush hour not exceeding 400 passengers per train. At what are regarded as terminal stations on tube railways no less than 3,512 trains arrived in the day. The maximum seating capacity at rush hours on the City and South London Railway was 150 passengers per train. On no tube railway did it exceed 350 seats.

Speaking generally of Greater London railway traffic, the ratio of seats provided per day to number of passengers carried is higher than in other large European or American centres of population. This contributes greatly to the comfort of the travelling public; as will be shown, it has a corresponding effect on the cost of transit.

The average speed on trunk railways within the Metropolitan area varied from 20 to 30 miles per hour. On tube railways it varied from 14·8 miles (City and South London Railway) to 20·8 miles per hour (Great Northern and City Railway, now incorporated with the Metropolitan Railway).

The capital cost of local standard lines averaged £525,000 per mile of route, varying from £330,000 per mile in the case of the North London Railway, to £700,000 in the case of the Whitechapel and Bow Railway. Portions of the Inner Circle were constructed at a cost exceeding £1,000,000 per mile. Working expenses averaged nearly 55 per cent. of gross receipts.

The capital cost of tube railways averaged £650,000 per mile of route, varying from £400,000 per mile in the case of the City and South London Railway, to over £800,000 in the case of the Great Northern and City Railway. Working expenses averaged nearly 50 per cent of gross receipts.

The average fare paid by passengers on all local lines amounted to 1·70*d.* and represented an average distance of 3 miles traversed.

*Tramways.*—The route mileage of tramways in the Metropolis is 348. It will be convenient to divide it into the London County Council system and the suburban system which is controlled by sixteen separate authorities.

The London County Council tramway system consists of 143·39 miles, of which 140 miles are constructed on the conduit system. In 1913 523,000,000 passengers were carried or 3,650,000 per mile of route. The capital cost averages £89,000 per mile. Working expenses accounted for 75 per cent. of gross traffic receipts. The average fare paid was 1·04*d.* per passenger covering a distance of 2 miles. The seating capacity of the cars is 78 and trailers are employed to a limited extent on part of the system. Although permitted on certain sections to travel at 20 miles per hour, the actual speed is rather less than 9. In reality there are two undertakings under a common administration with no physical connection. Both parts terminate in general, some considerable distance from the real traffic terminals.

The remaining 204 miles of tramways are on the overhead system of traction, constructional cost averaging £50,000 per mile of route. The total passengers carried were 290,000,000 or at the rate of 1,410,000 per mile. The average fare was 1·12*d.*, covering as before approximately 2 miles. Working expenses were 75 per cent. of gross receipts. The car seating capacity varied from fifty to seventy-eight, but trailers are not employed. These suburban systems terminate at the County boundary, and although all are of standard gauge, on only few routes has through running been established.

With all their imperfections in reaching real traffic terminals, tramways carried in 1913, 37 per cent. of the London passenger movement as against 33 and 30 per cent. by omnibus and railways respectively. On a largely increased traffic in 1918, the tramway percentage rose to 38 while omnibus traffic decreased to 26 per cent. and railway traffic increased to 36 per cent.

Although therefore tramways remain the largest passenger carrying agency in the Metropolis, this class of traffic is less developed in London than in the larger continental cities. This is not due to

the fact that other agencies supply the deficiency. London has more electric railways and omnibus routes than any of the European capitals. Yet the average number of journeys per head of population was smaller than in Berlin, Milan, Paris, Brussels, Genoa and Turin, being in fact only 75 per cent. of the first named. The railway and omnibus traffic of London per head of population is greater than in any of these cities. Table VI shows the position regarding tramways.

Table VI.—Tramway Track and Traffic in European Cities.

| City. | Miles of Track per 100,000 of Population. | Journeys by Tram per Head of Population. |
|---|---|---|
| Milan | 20·0 | 265 |
| Brussels | 16·5 | 252 |
| Genoa | 17·7 | 251 |
| Turin | 14·5 | 228 |
| Berlin | 7·3 | 190 |
| Budapest | 8·2 | 184 |
| Hamburg | 7·2 | 175 |
| Antwerp | 11·0 | 162 |
| Vienna | 8·1 | 155 |
| Paris | 10·0 | 113 |
| London | 4·7 | 113 |

These figures relate to the year 1913, in which year the Paris system was being reconstructed and the tramway traffic therefore greatly impeded.

*Motor Omnibuses.*—The number of passengers carried by motor omnibuses in 1913 totalled 736,000,000, of which nearly 711,000,000 were transported by the London General Omnibus Company and its associates. The figures which follow relate to this group.

The number of omnibuses employed during the year averaged 2,461 and the length of route covered approximated 400 miles. The capital of the Company amounted to £3,150,000. This is equivalent to £1,280 per bus or nearly £8,000 per mile of route. The traffic density varied enormously on the system but averaged

nearly 1,780,000 passengers per mile of route. Where in competition with tramways, the same fare was charged but no reduction was made in price for return tickets. Off tramway routes the average fare charged was higher. Passenger receipts averaged 1·32*d.* but did not cover a longer journey than in the case of tramways, i.e., 2 miles. Working expenses absorbed 86 per cent. of traffic receipts. The nominal capacity of the omnibus was thirty-four seats. Owing, however, to the absence of roof covers, the imposition of which would have rendered the vehicles unstable, in inclement weather the outside seats were scantily utilized, and enumeration of a considerable number of omnibuses under such conditions showed an average of seven seats utilized out of sixteen provided at times when tramcars were fully loaded in and out. In inclement weather the omnibus cannot be rated higher than providing twenty-three seats.

The speed at which omnibuses run varies largely. Nominally limited to 12 miles per hour, within an area having a radius of ½ mile from the Bank a higher rate than 4 miles per hour is frequently impracticable. With a clear road, a speed exceeding 14 miles per hour can be easily maintained. The schedule speed is approximately 9 miles per hour. Motor omnibuses reach all important traffic points in the Metropolis and are the only general passenger transit agency not restricted by specific statutory enactments. Consequently they escape a number of financial obligations to which tramways are subject. They are also exempted from affording special facilities for unremunerative traffic at workmen's fares to which all railed traction has to submit.

When constituting financial comparisons between the cost of omnibuses and other means of transit, it must be borne in mind that part of the cost of operation is defrayed by local rates. Unless a smooth hard surface is provided, operating costs and repairs increase at an alarming rate. It is the inferiority of street paving in continental cities as compared with London which has caused omnibuses to be so little employed in such centres. This is not intended either as an argument for inferior roads or for imposing taxation on omnibuses. It is merely recorded as a statement of fact.

*General.*—The Metropolitan District, Central London, City and South London, and London Electric Railways, together with all Tramways in the Metropolis, not municipally operated, and all Motor Omnibus Companies, are co-ordinated by the Underground Electric Railways of London, popularly known as the "Combine," and worked as one system. The Metropolitan Railway and the

nine great trunk railways are entirely independent, although all at present are under the control of the new Ministry of Transport.

The remaining tramways belong to eleven municipal corporations and are worked almost completely on independent lines. In the south of London, where the bulk of tramway traffic exists, there is no through running whatever.

The public highway is under the control of some 170 local authorities, with more or less limited functions. The areas and populations controlled differ enormously. All are maintained out of local rates, the majority being entitled to run or veto the running of tramways but not of omnibuses. There is at present (September 1st, 1919) no central co-ordinating authority although the need for one has been repeatedly demonstrated and admitted.

The Advisory Board of Engineers, previously referred to, commented in their report in 1905 on the situation as follows:—

> "The prime cause of London's backwardness is to be found in the lack of homogeneity in its municipal system and an entire absence of any centralized control and of consequent guiding effort which such control ensures."

There has been no change since.

### Characteristics of London Traffic.

*The Rush Hours.*—The capital and working costs of tube railways, tramways and motor omnibuses per mile of route in Greater London have been stated to be as follows:—

| | Capital Costs per Mile. | Working Costs in Percentage of Traffic Receipts. |
|---|---|---|
| | £ | |
| Tube railways . . . . . | 650,000 | 50 |
| Tramways (conduit) . . . . . | 89,000 | 75 |
| ,, (overhead) . . . . . | 50,000 | 75 |
| Motor omnibuses . . . . . | 8,000 | 86 |

Capital and working costs therefore differ inversely and with equal fare rating and conditions of service, there is a definite traffic volume which renders in each case the employment of one or the other type more economical. Capital costs in the case of the motor omnibus can be closely adjusted to the amount of subsequent user. With tramways and tube railways, however, 60 and 80 per cent. of

total capital expenditure will be entirely independent of the quantity of traffic carried. Taking interest at 5 per cent., the dead weight annual charges per mile would be:—

| | |
|---|---|
| Overhead tramways . . . . . | £1,500 per annum |
| Conduit tramways . . . . . | £2,670 „ „ |
| Tube railways . . . . . | £26,000 „ „ |

If working expenses could be ignored and a uniform charge of the fare rating adopted by the motor omnibus in 1913 were applied to all systems, i.e., 0·66*d.* per mile, the number of passenger miles to be run on overhead tramways, conduit tramways and tube railways would require to be at least 540,000, 961,000, 9,360,000 miles respectively, greater than those justifying the institution of a motor omnibus service. Working expenses, however, are far from being negligible. The traffic output of railways, tramways and omnibuses is by no means given under identical conditions. The furnishing of transit facilities offers some close analogies with electricity supply. The cost of output varies not merely according to the load but even more according to the variability of the load.

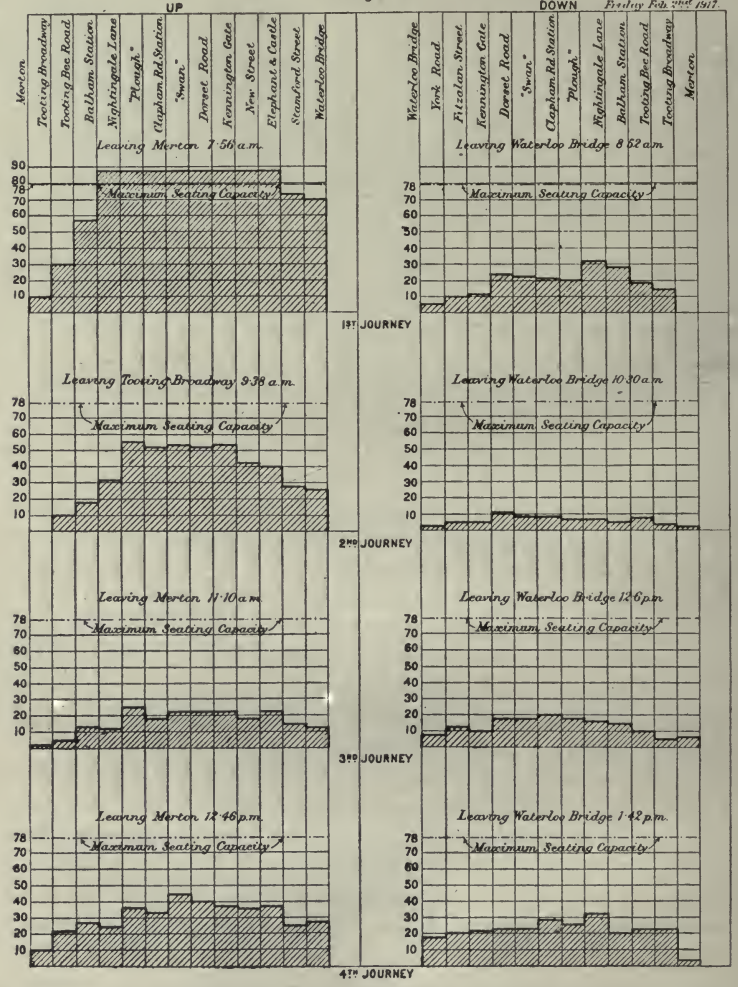
The maximum pressure on traffic instruments within the London area occurs generally between 8 a.m. and 9 a.m.[1] It cannot be too strongly insisted upon that traffic within that hour constitutes the most vital portion of the Metropolitan passenger movement. The dormitories of London empty and employers and employed leave their homes to congregate within the central area to pursue their various occupations. There is no "joy-riding" at that hour.

In the evening there is the return homeward rush, but the peak rarely reaches the intensity of the morning hour. The morning rush lasts about two hours, with a maximum intensity in the quarter just before 9 a.m. The evening rush is longer, from 5 p.m. to 8 p.m., and is far more uniformly distributed. At rush hours every seat in every instrument of transit is fully utilized. This is no new feature caused by war conditions. The rush hour traffic is characteristic of all large urban centres, and thanks to the radial form of the London population distribution, it does not reach, bad as it is, the intensity prevailing in New York, where traffic flows more concentratedly along a few parallel routes. These features of the London traffic movement are clearly brought out in *Fig. 6*,

[1] The recent general reduction in the hours of labour is, however, likely to alter the relative intensity of morning and evening peaks. The overlapping of the period of general cessation of work and of the largely increased return shopping movement is likely to accentuate the evening peak and create further transport difficulties. Figures relating to later months of the current year for certain routes in the central and western areas of London indicate that this is already taking place.

which shows the load on a typical tramcar throughout the day. The diagram may be taken as showing the conditions under which not only tramways but railways also work throughout the day.

*Fig. 6.*



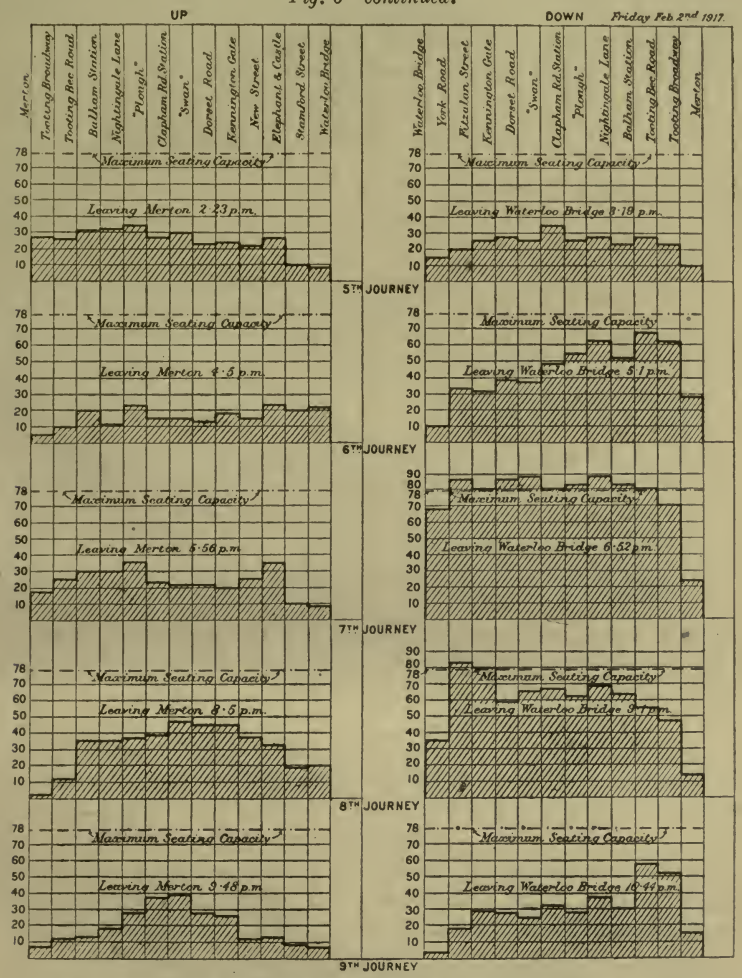

London County Council Tramways: Merton Circular Route. Passenger Load on One Car throughout the Day.

The resemblance to the trunk railway load is very close indeed. On the tube railways passing through the western half of the central area and beyond, the conditions are not quite so extreme.

*Load Diversity.*—Apart from a few all-night tramcars and trains

on the Great Eastern Railway, the London passenger movement lasts from 4 a.m. to one hour after midnight. Omnibuses generally start later and terminate earlier. The services taper off at both

*Fig. 6—continued.*




LONDON COUNTY COUNCIL TRAMWAYS: MERTON CIRCULAR ROUTE. PASSENGER LOAD ON ONE CAR THROUGHOUT THE DAY.

ends, and the overwhelming bulk of the London passenger movement takes place in the 16 hours from 7 a.m. to 11 p.m. This period has therefore been taken in the investigation which follows as representing the normal working day.

The average number of passengers on tube railways booked per car-mile run in 1913 was 5·3, each passenger travelling 3 miles. There were, on the average, therefore nearly 16 passengers in each car at a time. The police have no power to forbid overcrowding. For one hour at least in the day the car in each direction contained not less than 60 passengers. The ratio of passenger miles per car mile run during that hour to the mean of the remaining 15 hours was 4·6 to 1. This ratio may be called "the load diversity."

In the case of tramcars no overloading was permitted, and the number of passengers booked per car mile was 8·82. The load diversity was 5·75.

Omnibuses booked 6·8 passengers per bus mile. The ratio of load diversity was 2·8.

In 1918 the police allowed a certain proportion of standing passengers both in tramcars and omnibuses, increasing their capacity to 90 and 39 respectively. The number of passengers booked per mile on tubes, tramways and omnibus routes increased to 6·6, 13·24, and 9·0 respectively. The ratios of load diversity became 3·5, 4·1 and 2·3 in each case.

There is little doubt that, owing to competitive working in 1913, and more particularly in the case of tramways, the seat mileage run at other than rush hours was largely in excess of public requirements. This inflated the load diversity. It was equally notorious that in 1918, and still more in the earlier part of the current year, the accommodation provided at nearly all times fell short of public demand and convenience. The mean of the two years may therefore be taken as indicating the reasonable load diversity under which tubes, tramways and omnibuses work. This gives figures of 4, 4·9, and 2·5 respectively.

It is interesting to compare these ratios with the load diversity of the Great Eastern Railway, which has the largest suburban traffic of the trunk lines. In 1913 it was 5·8. The maximum number of passengers arriving in any half-hour of the 16 was 50 times greater than the minimum within a similar period. In 1918 the load diversity had increased to 6. As a greater ratio increases the difficulty of providing transport, in addition to other heavy burdens, the suburban passenger work of the Great Eastern Railway proved in war even more arduous than at normal times.

There is every inducement of self-interest on the part of transit agencies to reduce unnecessary running. This applies in particular to such undertakings the capital costs of which are limited. On the other hand, to refrain from carrying a fair proportion of the rush-hour traffic, which is the direct cause of the load diversity, throws an undue burden on other transit agencies. It is interesting,

therefore, to examine the provision made for meeting the time of maximum pressure and its effect on subsequent running on the part of trunk lines and tubes, tramways and omnibuses. Table VII records the result, and indicates the provision made during the 12 hours from 8 a.m. to 8 p.m., the direction being in every case inwards to the central area. It will be noted that the enumeration of tube trains, tramcars and omnibuses has been taken at practically the same spot. The figures relate to the summer months of the current year:—

Table VII.—Hourly Passenger Traffic Provision made by Transit Agencies.

| Hour. | Suburban Trains at Liverpool Street Station, Inwards only. | Cars in Tube Trains at Chancery Lane Proceeding to the City. | Tramcars at Junction of Gray's Inn Road and Holborn, Inwards only. | Omnibuses at Holborn Proceeding to the City. |
|---|---|---|---|---|
| a.m. | | | | |
| 8–9 | 38 | 126 | 71 | 100 |
| 9–10 | 34 | 150 | 70 | 117 |
| 10–11 | 13 | 108 | 49 | 116 |
| 11–12 | 9 | 72 | 47 | 113 |
| p.m. | | | | |
| 12–1 | 10 | 78 | 47 | 107 |
| 1–2 | 10 | 90 | 47 | 117 |
| 2–3 | 9 | 96 | 47 | 119 |
| 3–4 | 11 | 99 | 48 | 117 |
| 4–5 | 19 | 132 | 58 | 119 |
| 5–6 | 22 | 162 | 60 | 118 |
| 6–7 | 29 | 138 | 62 | 111 |
| 7–8 | 15 | 75 | 61 | 108 |

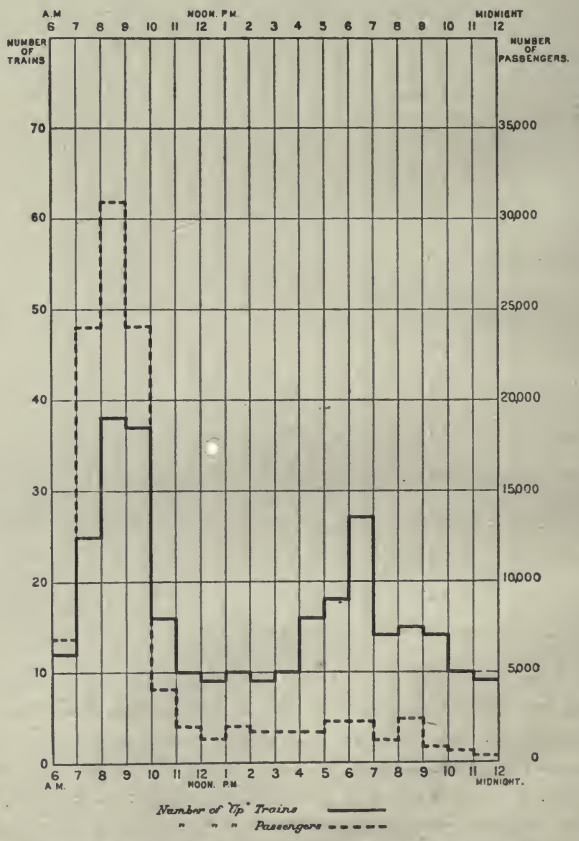
It will be observed that when trains at Liverpool Street and tramcars at Holborn were at their maximum, the number of omnibuses was least. The reverse conditions also applied.

The number of trains and tramcars proceeding inwards between 4 p.m. and 8 p.m. were not intrinsically required for the inward traffic but to provide the necessary accommodation for the return homeward movement. The greater the provision for peak traffic, the greater, therefore, the vacant seat capacity. The provision made to meet rush traffic is brought out more clearly by contrasting

the number of seats provided than the mere enumeration of vehicles. The following statement records the facilities furnished during the hour when the pressure is greatest and least respectively :—

| Hour. | Trains at Liverpool Street Station, Inwards. | Tube Trains at Chancery Lane, Inwards. | Trams at Gray's Inn Road, Inwards. | Omnibuses at Holborn, Inwards. |
|---|---|---|---|---|
| | Number of Seats. | Number of Seats. | Number of Seats. | Number of Seats. |
| 8–9 a.m. | 26,600 | 6,048 | 5,538 | 3,400 |
| 2–3 p.m. | 6,300 | 4,608 | 3,666 | 4,046 |

*Fig. 7.*



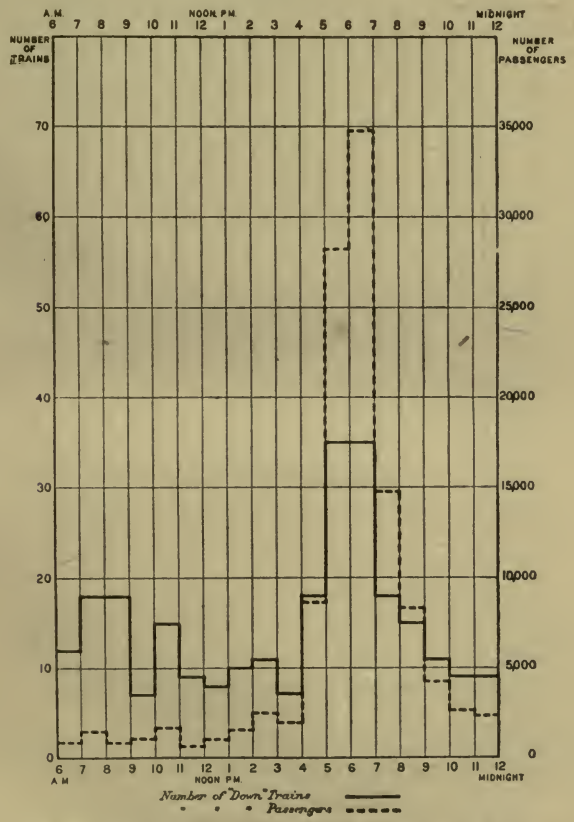

HOURLY NUMBER OF UP TRAINS AND PASSENGERS AT LIVERPOOL STREET STATION, G.E.R.

To meet rush traffic, a unit of large capacity is economical. Railways and tramways increase the number of trains and trams, and add coaches and trailers. At other hours there is surplus accommodation even when, as in the case of tramways, one-third of the cars are returned to shed. At these periods, an omnibus could easily carry the tramcar load, and the tramcar that of the railway train.

The salient features of the London traffic movement are shown in the diagrams on pp. 32–36.

*Figs. 7* and *7a*.—Hourly number of trains and passengers, inwards and outwards, at Liverpool Street Station of the

*Fig. 7a.*

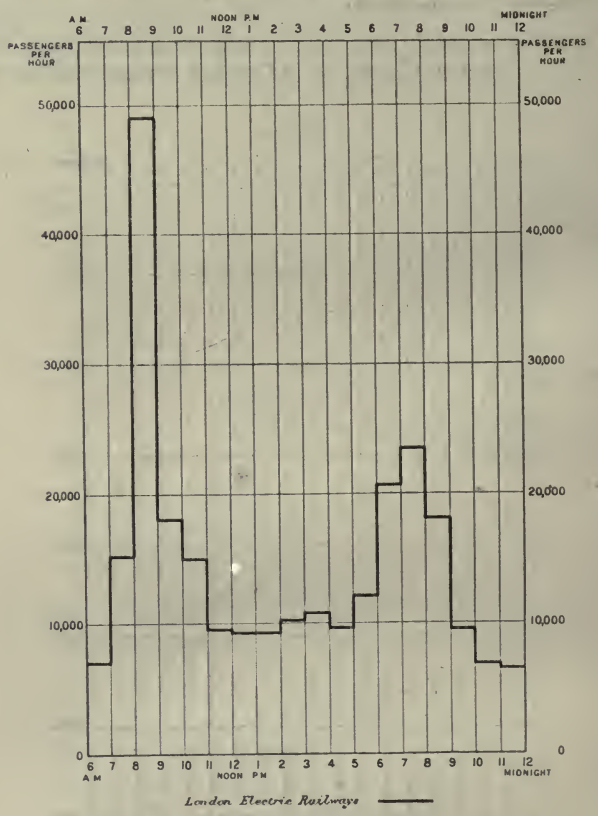



HOURLY NUMBER OF DOWN TRAINS AND PASSENGERS AT LIVERPOOL STREET STATION, G.E.R.

Great Eastern Railway to show the character of suburban traffic.

*Fig. 8.*—Number of passengers carried hourly by the London Electric Railways, to show character of tube railway traffic. (This diagram is replotted from a Paper read before the American Engineering Congress, 1915, by the Right Hon. Sir Albert Stanley, M.P.)

*Fig. 8.*

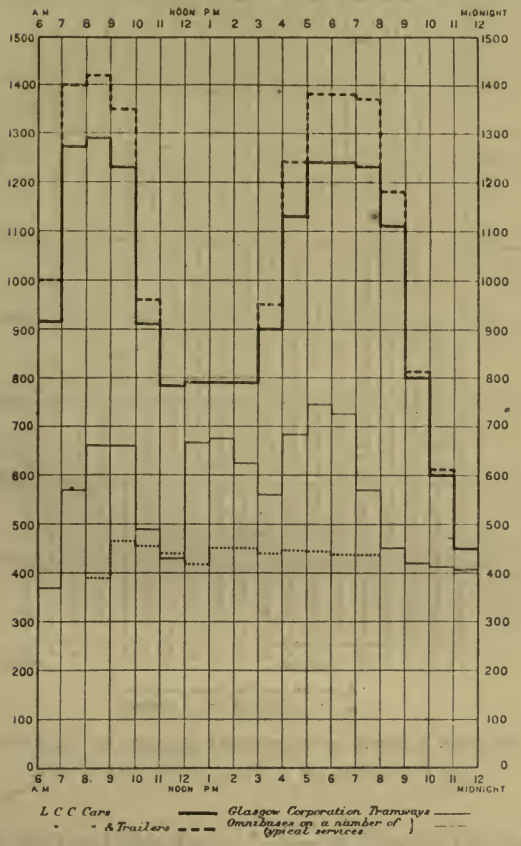



HOURLY NUMBER OF PASSENGERS CARRIED ON THE LONDON ELECTRIC RAILWAYS.

*Fig. 9.*—Hourly number of tramcars employed on the London County Council tramway system and number of omnibuses hourly on certain popular routes. To

show the effect of the mid-day load, which in London only omnibuses enjoy, the number of cars on the Glasgow Corporation tramways are also shown.

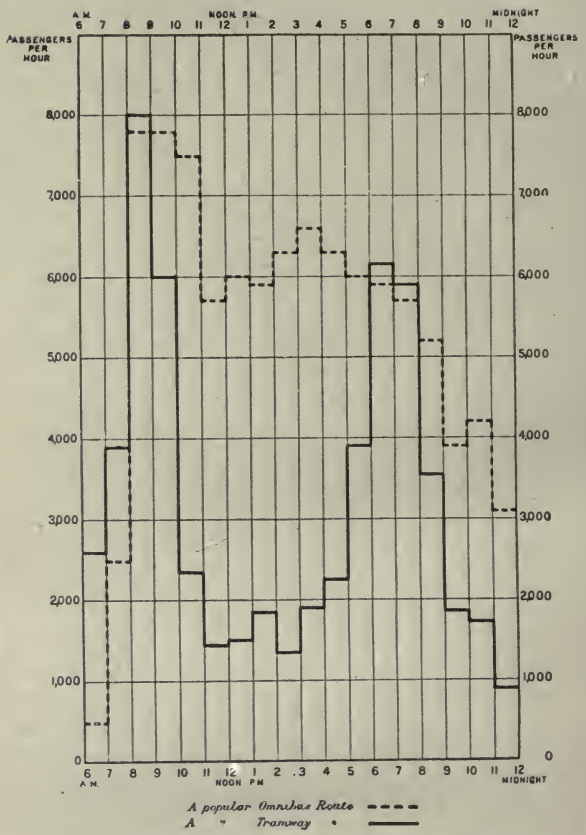
*Fig. 9.*




HOURLY NUMBER OF TRAMCARS EMPLOYED ON THE L.C.C. AND GLASGOW CORPORATION TRAMWAYS, AND ON TYPICAL OMNIBUS SERVICES IN LONDON.

*Fig. 10.*—Hourly number of passengers carried by tramways and omnibuses, in each case on a typical popular route.

*Fig. 10.*




HOURLY NUMBER OF PASSENGERS CARRIED BY TRAMCARS AND OMNIBUSES ON A TYPICAL POPULAR ROUTE.

*Effect of load diversity on cost of transit.*—It has been shown that to meet the hourly varying demands made on transit agencies a considerable amount of waste seat mileage is unavoidable. The load diversity and the actual number of seats provided to seats occupied which characterized the operations of the various transit agencies in London in 1913 and 1918 are shown in the following Table :—

TABLE VIII.—LOAD DIVERSITY AND TRAFFIC ACCOMMODATION.

| | Year 1913. | | Year 1918. | |
|---|---|---|---|---|
| | Load Diversity. | Ratio of Seat to Passenger Miles. | Load Diversity. | Ratio of Seat to Passenger Miles. |
| Omnibus . . . | 2·8 | 2·5 | 2·3 | 1·75 |
| Tramway . . . | 5·75 | 4·4 | 4·1 | 2·9 |
| Tube railway . . | 4·6 | 3·0 | 3·5 | 2·44 |

If these figures be plotted it will be seen that a 75-per-cent. line represents the mean fairly closely. This seems to indicate that the total practical provision made in London to meet varying degrees of load diversity does not exceed three-fourths of that variation. To insist that every passenger at the rush hours shall have a seat provided entails at other times so much waste capacity as to increase materially the cost of transit.

In the case of the motor omnibus, the ratio of seat to passenger miles appears to be higher than 75 per cent. of the load diversity. This is partly due to the fact that the carrying capacity of the omnibus has been taken at all times and under all climatic conditions to be 34 seats. This makes the ratio of seats provided seem higher than is intrinsically the case. As, however, the assumption that for any given degree of load diversity the ratio of seat to passenger miles need be no higher than 75 per cent. is favourable to the omnibus by increasing its apparent capacity, this 75 per cent. has been taken to apply to omnibuses as well as to tramcars and tube railways.

The three Tables in the Appendix give the financial results of omnibus, tramway and tube railway operation at varying load diversities. They have been calculated on the following data and assumptions:—

Capital and Working Costs:—Taken from official accounts and stated in terms of "per mile of route."

Amount Available for Dividends:—An average of 5 per cent.

Depreciation:—Omnibus. On two-thirds of the capital, this proportion representing the cost of actual vehicles, 20 per cent. per annum.

(2) Tramways. 4 per cent. on the whole capital, giving in accordance with Treasury Regulations a 25-year life to the undertaking.

(3) Tube Railways. 8½ per cent. on one-fifth of the capital, this amount representing wasting assets.

Strictly speaking, depreciation for 1918 should be taken at a higher rate than for 1913, in view of increased costs. Having regard, however, to the uncertainty still prevailing as to future prices, it has been thought better to use the same figure for both years, with this cautionary remark:—To the extent in which the proportion of wasting to total assets is increased, in that ratio the results for 1918 are made to appear unduly favourable.

Revenue:—The fare rating per mile charged by omnibuses in 1913 and in 1918 has been applied both to tramways and tube railways.

As a fact, the fare rating on transit agencies in London was not uniform either in 1913 or 1918. In the former year, the omnibus fare rating was 16 and 31 per cent. higher than on tube railways and tramways, respectively; in the latter year it was 32 and 31 per cent. higher, respectively.

In drawing conclusions from the Tables it should be noted that the results recorded correspond with the actual carrying capacity provided. In 1913 there were approximately six omnibuses, nine tramcars, two 5-car tube trains per mile of route. Within definite limits this capacity can be increased in the case of omnibuses by additional capital expenditure corresponding to nearly the whole of the capital; in the case of tramways, by increase in 40 per cent. of the capital; and in the case of tube railways, by increase in 20 per cent. of the capital.

In so far as surface traction is concerned, it should finally be pointed out that the comparison is between motor omnibuses running on the well-paved streets of the metropolis and conduit tramways, the capital costs of which are nearly 80 per cent. higher than those entailed by tramways on the overhead system.

The operating cost per seat mile provided by various transit agencies is a function of the system employed, and is affected only to a moderate extent by increase or decrease in total mileage. Thus in the ten years ending 1915, the London County Council tramway mileage differed by 200 per cent., but working costs per mile run, and consequently seat-mile costs, did not vary 10 per cent. If allowance be made for increased mechanical efficiency, a similar result is shown in motor omnibus operation. The cost per passenger mile, however, is not merely a function of the type. It

is the product of the type and load diversity. Any initial difference in working costs of particular systems becomes accentuated with increase in load diversity.

TABLE IX.—INCOME, WORKING COSTS, AND LOAD DIVERSITY.

| | Load Diversity. | | | | |
|---|---|---|---|---|---|
| | **2** | **3** | **4** | **5** | **6** |
| *Year 1913.* | *d.* | *d.* | *d.* | *d.* | *d.* |
| Fare rating per passenger-mile . . . . . | 0·66 | 0·66 | 0·66 | 0·66 | 0·66 |
| Cost per seat-mile :— | | | | | |
| Omnibus. . . . . | 0·208 | 0·208 | 0·208 | 0·208 | 0·208 |
| Tramway . . . . | 0·085 | 0·085 | 0·085 | 0·085 | 0·085 |
| Tube railway . . . | 0·102 | 0·102 | 0·102 | 0·102 | 0·102 |
| Cost per passenger-mile :— | | | | | |
| Omnibus . . . . | 0·312 | 0·468 | 0·624 | 0·780 | 0·936 |
| Tramway. . . . . | 0·127 | 0·191 | 0·255 | 0·319 | 0·382 |
| Tube railway . . . | 0·153 | 0·229 | 0·306 | 0·382 | 0·459 |
| *Year 1918.* | | | | | |
| Fare rating per passenger-mile . . . . . | 0·85 | 0·85 | 0·85 | 0·85 | 0·85 |
| Cost per seat-mile :— | | | | | |
| Omnibus. . . . . | 0·412 | 0·412 | 0·412 | 0·412 | 0·412 |
| Tramway. . . . . | 0·183 | 0·183 | 0·183 | 0·183 | 0·183 |
| Tube railway . . . | 0·139 | 0·139 | 0·139 | 0·139 | 0·139 |
| Cost per passenger-mile :— | | | | | |
| Omnibus . . . . . | 0·618 | 0·927 | 1·236 | 1·545 | 1·854 |
| Tramway. . . . . | 0·274 | 0·412 | 0·549 | 0·686 | 0·823 |
| Tube railway . . . | 0·210 | 0·313 | 0·417 | 0·521 | 0·626 |

A number of interesting deductions can be drawn from this Table. Any comparison of types of traffic instruments on the basis of the relationship between working costs and receipts can be only approximate unless the degree of load diversity be the same.

With the same vehicle and working costs, a given fare rating may be either excessive or deficient according to the degree of load diversity.

With equal load diversity, the justification for capital expenditure will be determined by the difference between the fare rating and working costs, multiplied by the traffic volume to be dealt with.

It has been stated that the effect of load diversity is to accentuate any initial difference in operating costs. Its influence on revenue and on capital charges is similarly prejudicial. As load diversity increases, the number of passenger miles in relationship to the total seat miles is reduced. With a uniform fare rating the revenue is

TABLE X.—CAPITAL CHARGES AND LOAD DIVERSITY.

| | Load Diversity. | | | | |
|---|---|---|---|---|---|
| | 2 | 3 | 4 | 5 | 6 |
| *Year 1913.* | *d.* | *d.* | *d.* | *d.* | *d.* |
| Capital charges per seat-mile :— | | | | | |
| Omnibus . . . . | 0·040 | 0·040 | 0·040 | 0·040 | 0·040 |
| Tramways . . . . | 0·059 | 0·059 | 0·059 | 0·059 | 0·059 |
| Tube railways . . . | 0·251 | 0·251 | 0·251 | 0·251 | 0·251 |
| Capital charges per passenger-mile :— | | | | | |
| Omnibus . . . . . | 0·060 | 0·090 | 0·019 | 0·149 | 0·179 |
| Tramways . . . . | 0·090 | 0·132 | 0·176 | 0·220 | 0·264 |
| Tube railways . . . | 0·377 | 0·565 | 0·755 | 0·945 | 1·134 |
| *Year 1918.* | | | | | |
| Capital charges per seat-mile :— | | | | | |
| Omnibus . . . . . | 0·068 | 0·068 | 0·068 | 0·068 | 0·068 |
| Tramways . . . . | 0·071 | 0·071 | 0·071 | 0·071 | 0·071 |
| Tube railways . . . | 0·173 | 0·173 | 0·173 | 0·173 | 0·173 |
| Capital charges per passenger-mile :— | | | | | |
| Omnibus . . . . . | 0·102 | 0·153 | ·204 | 0·254 | 0·305 |
| Tramways . . . . . | 0·107 | 0·161 | 0·215 | 0·269 | 0·322 |
| Tube railways . . . | 0·260 | 0·390 | 0·520 | 0·650 | 0·780 |

therefore diminished. Capital charges, however, remain constant, and have to be spread over a reduced number of passenger miles.

On the assumption that the various transit agencies have to meet all the capital charges and working costs previously mentioned, from the combination of Tables IX and X for the year 1913, the following deductions can be drawn :—

*Load Diversity 2.*

| | Minimum Number of Passengers Required to Obviate any Loss, per Mile of Route. | Carrying Capacity of Existing System per Mile of Route. |
|---|---|---|
| Omnibus . . . . . | 500,000 | 2,950,000 |
| Tramway . . . . . | 1,800,000 | 10,800,000 |
| Tube railways . . . . . | 6,900,000 | 9,220,000 |

Tramway and omnibus passengers are assumed to travel two miles and tube railway passengers three miles on the average, respectively.

*Load Diversity 3.*

| | Minimum Number of Passengers Required to Obviate any Loss, per Mile of Route. | Carrying Capacity of Existing System per Mile of Route. |
|---|---|---|
| Omnibus . . . . . | 900,000 | 1,960,000 |
| Tramways . . . . . | 2,050,000 | 7,250,000 |
| Tube railway . . . . . | .. | 6,150,000 |

Tube railways cannot run without financial loss at the assumed fare rating at this or any other higher degree of load diversity.

*Load Diversity 4.*

| | Minimum Number of Passengers Required to Obviate any Loss per Mile of Route. | Carrying Capacity of Existing System per Mile of Route. |
|---|---|---|
| Omnibus . . . . . | .. | 1,475,000 |
| Tramway . . . . . | 2,350,000 | 5,450,000 |
| Tube railway . . . . . | .. | 4,610,000 |

With the given fare rating, a load diversity of 4 was just beyond the capacity of the omnibus.

*Load Diversity 5.*

The minimum number of passengers required by tramways to obviate loss was 2,750,000. The carrying capacity of the system was 4,350,000.

*Load Diversity 6.*

Tramways if carrying per mile of route their ultimate capacity at this degree of load diversity are just able to meet their financial requirements.

In 1918 capital and working costs had increased by 93 and 76 per cent. respectively in the case of omnibuses and tramways. On tube railways there was an actual decrease of 12 per cent. The reduction in capital charges, caused by more passenger miles being run, more than compensated for increased working costs. Accordingly, with a load diversity of $3\frac{1}{2}$ and 8,000,000 passengers per mile of route tube railways met all their obligations.

Tramways, on the other hand, failed if the diversity exceeded $4\frac{1}{2}$ and the number of passengers at that diversity did not exceed 4,000,000 per mile of route.

As was to be expected, increase in working costs affected the motor omnibus most of all. Where the diversity exceeded $2\frac{1}{2}$, even with the high fare rating employed, it ceased to be financially satisfactory. In the early part of 1919 omnibuses were said to be working at an actual financial loss.

## The Function of Tube Railways in London Traffic.

Table X clearly shows, even for the year 1918, how heavily tube railways suffer from the handicap of capital charges. In any large urban centre it would be futile to hope for a lower load diversity than 3. It will be seen from the results recorded in the Appendix, that with this degree of load diversity, tramways on half the capacity, and involving only one-ninth the construction costs, yield results which are nearly equal to those attained by tubes. At higher variations tramways compare still more favourably. These observations presuppose that in respect of services rendered, tube railways can only be permitted to levy surface traction charges. As at present worked it is difficult to justify a higher rate.

Tube railways are constructed with stations ½ mile apart in the hope of enabling effective competition with surface traction to be carried on. They have failed in this purpose. For distances up to 2 miles, the overwhelming bulk of surface traction, they are generally slower and less convenient. Their lay-out is on no comprehensive, definitely preconceived plan. There exists in consequence between the various lines at what are called interchange stations an enormous transfer of passengers carried out by traversing long tortuous passages and ascending and descending stairs. Where through journeys involve this change, surface traction competes successfully for distances considerably exceeding 2 miles. From Liverpool Street Station to Paddington, by way of the Central London and Baker Street–Waterloo Railways is nearly 6 miles. An omnibus follows practically the whole way on the surface. The same fare is charged and the journey on the average takes only 5 minutes longer. The very inconvenient transfer at Oxford Circus is obviated, and the advantage from the point of view of comfort is all with the motor omnibus. From a traffic point of view it is on the whole hard to justify, by reason of services rendered, the heavy tube railway capital costs. Tubes in London partake more of the character of deep-level tramways than of railways and have tramway rather than railway characteristics.

As instruments of traffic, tramways, tubes, and to a lesser extent local railways, differ from trunk lines in two important respects. (1) They cannot be economically employed for the conveyance of goods. (2) They suffer from a greater load diversity. These differences are fundamental.

In comparison with surface traction, operating costs on tube railways form only a fractional part of total charges. The length of haul is insufficient to enable actual economy in traction to overcome this initial disadvantage. The difficulties of competing are increased by the necessity of double handling. Terminal facilities are and must be restricted. Only one tube railway carries an insignificant parcel service. Goods traffic for short distances in the Metropolis can be more economically handled by surface motor traction than by railways.

Trunk railways by reason of the longer distances passengers travel are less affected by surface competition and are thus able to exercise greater discretion as to the actual time of running trains. By means of goods traffic they are further able to a greater extent to equalize the load on the track. Tube railways have none of these advantages. They must furnish facilities at any moment entirely in accord with public transit requirements. When there are few

or no passengers, there is little or nothing for them to do. Making all allowances for these differentiating features, it still remains true that in comparison with surface traction, the justification for the cost of tube railway construction must be furnished by the superior facilities they furnish purely as instruments of passenger transit. The meagre financial results which have accrued show that the measure of success achieved is not large.

The limits to which an urban centre will expand is very largely a function of the speed of transport and finds its expression in a period of time, which the population in general is prepared to expend for travelling to and from their work. In the year 1911 the equated density of population in Greater London, that is, weighting the area and population of each district relatively to the whole, was 62·27 inhabitants to the acre. In other words, the occupied portion of the metropolitan area could be comprised within a circle having a radius of 7·5 miles. Observation in London shows that 50 minutes approaches the maximum time limit devoted by the population to regular daily transit on each journey.

A distance of 7·5 miles can be encompassed by surface traction in about 50 minutes. The actual running time on the Central London Railway for a distance of $6\frac{3}{4}$ miles is 27 minutes. For surface traction a comparatively short period must be added for getting to the nearest main road. The time spent, however, in getting to the station, and the delay on station premises is far more material. It is fairly obvious that with all our present means of purely local transit, the 7·5 mile ring constitutes a limiting radius.

More than 60 per cent., however, of the inhabitants of Greater London live with an equated density of 85 to the acre. If the object to be aimed at is to spread the population over an area having approximately the density of the Borough of Hampstead, a circle having a radius of 10 miles would be requisite. This distance is far beyond the time limit for journeys by surface traction. It is beyond the time limit even of the Central London Railway. The possibility of effecting a solution of the Housing Problem in the Metropolis depends on the provision of a means of transport which shall have a speed substantially greater than now prevailing on tube railways. At a schedule speed of 25 miles per hour, a 10-mile journey occupies 24 minutes. This allows 26 minutes for walking to and from stations and for terminal delays. This margin, moreover, provides for the area necessary to furnish the traffic density requisite for railway working. No such results are possible with the present rate of speed and two stops per mile. A speed of even 20 miles per hour, not an excessive railway speed, involves starting

a mass of 150 tons from rest, accelerating it to a crest speed of nearly 30 miles per hour and then bringing it to rest again, the cycle being repeated 40 times per hour. The strain on generating stations, rolling stock and permanent way by an even higher rate of speed than now prevailing would be unduly severe and would prevent economic working or reasonably cheap fares. As, however, the average fare paid on tube railways indicates a distance of 3 miles travelled, it seems altogether unnecessary to stop six times in that distance in the hope of getting a few short distance passengers.

Equally unjustified is the attempt made by omnibuses and tramcars to attract long distance passengers by cheaper fares. Long distance surface transit is very largely confined to rush hour periods. It does not repeat to any considerable extent during the remainder of the day. It is the direct cause of the large load diversity on tramways.

The foundation of all surface transit systems is the passenger paying the minimum fare, giving a good load factor throughout the day. To this feature, the prosperity (until recently) of the omnibus was mainly due.

Omnibuses and tramways to-day seek to do the work of railways, and railways that of omnibuses and tramways. Such senseless uneconomic competition should be avoided by the proper co-ordination of the passenger transit systems in the metropolis.

## Co-ordination of Metropolitan Passenger Traffic.

Any attempt to restore omnibuses, tramways and tube railways to their proper functions is only possible if the system of working employed is such as will, by appeal to financial and general considerations, invoke and secure the co-operation of the travelling public. This co-operation can largely and automatically be secured by a more scientific system of fare rating. The following is suggested as the underlying principle to be adopted:—

*Tramways and Omnibuses.*—A low initial fare for short distances, the rate increasing with increase in distance.

*Local and Tube Railways.*—A high initial fare for short distances, the rate rapidly decreasing with increase in distance.

Fares based on these principles as applied to the popular omnibus and tube railway route from Liverpool Street to Shepherds Bush are shown in Appendix B.

Under such a system of fare rating consistently followed, long

distance passengers would save both time and money by use of railways; and for similar reasons short distance passengers would use surface traction. It would be unnecessary for tube trains to stop twice in every mile. Many of the less important stations could be closed; at others, only a limited number of trains would stop. A higher average rate of speed could be maintained without strain on equipment. Finally the carrying capacity of the system would be augmented or alternatively the present capacity be maintained at lower cost.

Such a scheme pre-supposes the harmonious co-operation of the passenger transportation systems, with through bookings at inclusive fares between underground and surface systems. The Rapid Transit Subway in New York has been equipped on certain sections with four tracks for express and stopping trains respectively. The same system in an even better form exists intrinsically in the Metropolis. The surface is the appropriate position for comparatively slow short-distance traffic; the tubes are admirably fitted for high speed, long distance transportation.

It may be urged that considerable inconvenience will be caused by having to use perhaps two instruments of transit for reaching ultimate destinations. Trains will still stop at all important stations. The time saved to the large bulk of the community by the closing of those less important will go far to redress any balance. Increased accommodation as the result of higher speed or the alternative of reduced cost will afford further compensation. Persons who for selfish individual reasons prefer a slow to a more rapid system of transit cannot claim to have a determining voice. On trunk railways, express trains only stop at important traffic centres. The analogy is not without significance in its application to local urban traffic.

The study of problems connected with traffic in large centres of population has interests of its own, and difficulties of its own. The difficulties are increased by lack of sufficient comparable scientific data and by the semi-political controversies they involve. Too often there is the tendency to assess the merits of urban traffic instruments in terms of ownership. The interest of the problem is, however, accentuated by the close and immediate bearing it has on the solution of pressing social questions. The impression deepest on the mind of one who for many years has tried to study the intricacies of the problem is, that patient investigation on scientific lines, previsional planning consistently pursued, utilization of all instruments of traffic—omnibuses, tramways, railways—in the way

they are respectively best suited for, form the only means whereby ultimate success can be achieved. The enunciation of the demand, the user of the instruments supplied, form the legitimate work of the traffic manager. But the supply of the actual means falls within the scope of the engineer, and create for him problems, in the solution of which there is abundant scope for his ingenuity and talents.

The Author desires to express his obligations to Mr. H. E. Blain, Operating Manager of the London Electric Railways, to Mr. A. L. C. Fell, M. Inst. C.E., General Manager of the London County Council Tramways, to Mr. F. Hunt and Mr. J. Calvert Spensley, Valuer and Assistant Valuers of the London County Council, and to Mr. S. A. Parnwell, Assistant Manager of the Great Eastern Railway, for having placed at his disposal some of the data on which this lecture is based.

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[Appendixes.

## APPENDIX A.

### Estimated Financial Results of Tube Railway Operation.

| Per Mile of Route. | Load Diversity. | | | | |
|---|---|---|---|---|---|
| | 2 | 3 | 4 | 5 | 6 |
| *Year 1913.* | | | | | |
| Car-miles | 864,000 | 864,000 | 864,000 | 864,000 | 864,000 |
| Seat-miles | 41,500,000 | 41,500,000 | 41,500,000 | 41,500,000 | 41,500,000 |
| Passenger-miles | 27,670,000 | 18,450,000 | 13,830,000 | 11,070,000 | 9,220,000 |
| | £ | £ | £ | £ | £ |
| Traffic revenue | 76,700 | 51,250 | 38,300 | 29,700 | 25,600 |
| Working costs | 17,700 | 17,700 | 17,700 | 17,700 | 17,700 |
| Surplus or deficit | 59,000 | 33,550 | 20,600 | 12,000 | 7,900 |
| Capital charges | 43,500 | 43,500 | 43,500 | 43,500 | 43,500 |
| Final surplus or deficit | 15,500 | −9,950 | −22,900 | −31,500 | −35,600 |
| *Year 1918.* | | | | | |
| Car-miles | 1,250,000 | 1,250,000 | 1,250,000 | 1,250,000 | 1,250,000 |
| Seat-miles | 60,000,000 | 60,000,000 | 60,000,000 | 60,000,000 | 60,000,000 |
| Passenger-miles | 40,000,000 | 26,670,000 | 20,000,000 | 16,000,000 | 13,300,000 |
| | £ | £ | £ | £ | £ |
| Traffic revenue | 142,000 | 94,500 | 71,000 | 56,800 | 47,300 |
| Working costs | 35,000 | 35,000 | 35,000 | 35,000 | 35,000 |
| Surplus or deficit | 107,000 | 59,500 | 36,000 | 21,800 | 12,300 |
| Capital charges | 43,500 | 43,500 | 43,500 | 43,500 | 43,500 |
| Final surplus or deficit | 63,500 | 16,000 | −7,500 | −21,700 | −31,200 |

The assumed average fare per mile in 1913 is 0·66*d*.
,, ,, ,, ,, ,, ,, ,, 1918 ,, 0·85*d*.

## Estimated Financial Results of Tramway Operation.

| Per Mile of Route. | Load Diversity. 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|
| *Year 1913.* | | | | | |
| Car-miles | 418,600 | 418,600 | 418,600 | 418,600 | 418,600 |
| Seat-miles | 32,600,000 | 32,600,000 | 32,600,000 | 32,600,000 | 32,600,000 |
| Passenger-miles | 21,730,000 | 14,500,000 | 10,870,000 | 8,700,000 | 7,250,000 |
| | £ | £ | £ | £ | £ |
| Traffic revenue | 60,400 | 40,300 | 30,200 | 24,200 | 20,100 |
| Working costs | 11,600 | 11,600 | 11,600 | 11,600 | 11,600 |
| Surplus or deficit | 48,800 | 28,700 | 18,600 | 12,600 | 8,500 |
| Capital charges | 8,000 | 8,000 | 8,000 | 8,000 | 8,000 |
| Final surplus or deficit | 40,800 | 20,700 | 10,600 | 4,600 | 500 |
| *Year 1918.* | | | | | |
| Car-miles | 343,000 | 343,000 | 343,000 | 343,000 | 343,000 |
| Seat-miles | 26,800,000 | 26,800,000 | 26,800,000 | 26,800,000 | 26,800,000 |
| Passenger-miles | 17,870,000 | 11,910,000 | 8,930,000 | 7,150,000 | 5,960,000 |
| | £ | £ | £ | £ | £ |
| Traffic revenue | 63,500 | 42,300 | 31,600 | 25,300 | 21,100 |
| Working costs | 20,400 | 20,400 | 20,400 | 20,400 | 20,400 |
| Surplus or deficit | 43,100 | 21,900 | 11,200 | 4,900 | 700 |
| Capital charges | 8,000 | 8,000 | 8,000 | 8,000 | 8,000 |
| Final surplus or deficit | 35,100 | 13,900 | 3,200 | − 3,100 | − 7,300 |

The assumed average fare per mile in 1913 is 0·66*d*.
" " " " " " 1918 " 0·85*d*.

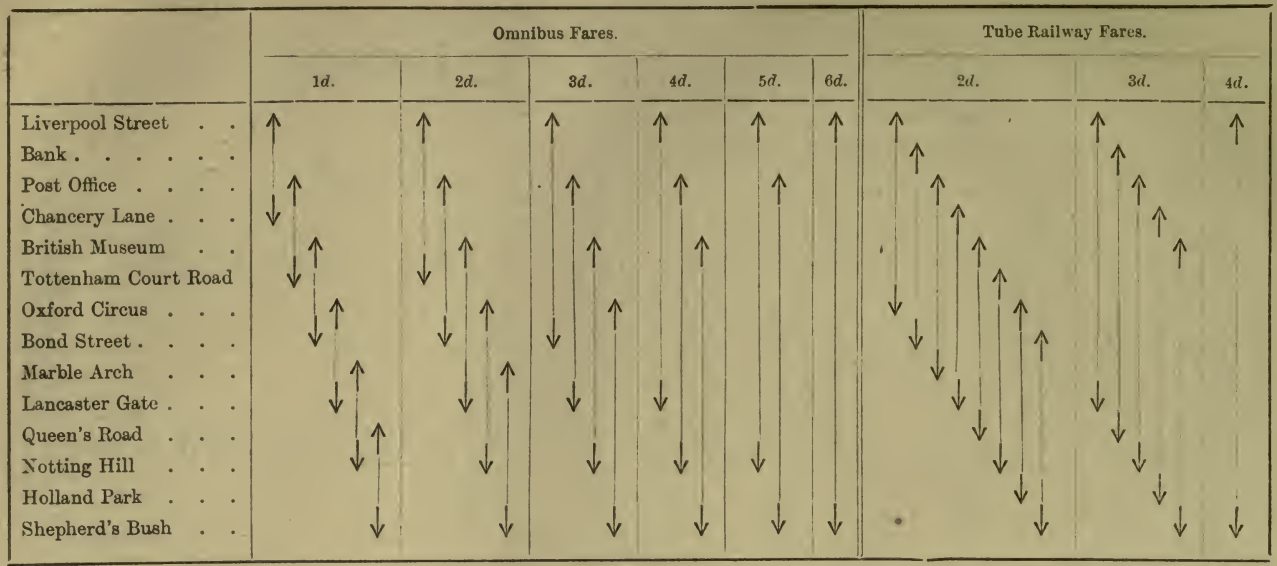
ESTIMATED FINANCIAL RESULTS OF MOTOR OMNIBUS OPERATION.

| Per Mile of Route. | Load Diversity. | | | | |
|---|---|---|---|---|---|
| | 2 | 3 | 4 | 5 | 6 |
| *Year 1913.* | | | | | |
| Bus-miles | 260,000 | 260,000 | 260,000 | 260,000 | 260,000 |
| Seat-miles | 8,840,000 | 8,840,000 | 8,840,000 | 8,840,000 | 8,840,000 |
| Passenger-miles | 5,900,000 | 3,930,000 | 2,950,000 | 2,360,000 | 1,960,000 |
| | £ | £ | £ | £ | £ |
| Traffic revenue | 16,400 | 10,900 | 8,200 | 6,550 | 5,450 |
| Working costs | 7,700 | 7,700 | 7,700 | 7,700 | 7,700 |
| Surplus or deficit | 8,700 | 3,200 | 500 | −1,150 | −2,250 |
| Capital charges | 1,470 | 1,470 | 1,470 | 1,470 | 1,470 |
| Final surplus or deficit | 7,230 | 1,730 | −970 | −2,620 | −3,720 |
| *Year 1918.* | | | | | |
| Bus-miles | 153,000 | 153,000 | 153,000 | 153,000 | 153,000 |
| Seat-miles | 5,200,000 | 5,200,000 | 5,200,000 | 5,200,000 | 5,200,000 |
| Passenger-miles | 3,470,000 | 2,310,000 | 1,730,000 | 1,390,000 | 1,160,000 |
| | £ | £ | £ | £ | £ |
| Traffic revenue | 12,400 | 8,200 | 6,200 | 4,900 | 4,100 |
| Working costs | 8,950 | 8,950 | 8,950 | 8,950 | 8,950 |
| Surplus or deficit | 3,450 | −750 | −2,750 | −4,050 | −4,850 |
| Capital charges | 1,470 | 1,470 | 1,470 | 1,470 | 1,470 |
| Final surplus or deficit | 1,980 | −2,220 | −4,220 | −5,520 | −6,320 |

The average fare per mile in 1913 was 0·66*d*.
„ „ 1918 „ 0·85*d*.

## APPENDIX B.

### Suggested Scheme of Fares on a Typical Route.




*Note.*—Three-stage points, on the average ½ mile apart, constitute the penny omnibus fare, the fare rating being, as in 1913, 0·66*d.* per mile.

New fare stages begin only at alternate stages. This automatically increases the fare rating to long-distance passengers.

On tube railways the minimum fare is 2*d.*, but new fares begin at every station, the minimum fare covering six stages. Nine stages are given for 3*d.* and the whole route for 4*d.*

For distances exceeding 2½ miles at all points of the route, tube fares are generally lower than omnibus fares. For shorter distances omnibus fares are equal to or less than tube fares. The disinclination of traffic managers to allow odd halfpenny fares prevents the scheme being carried out in its entirety

## APPENDIX C.

### 1. Dates at which the Various Sections of the London Tube Railway System were Opened to Traffic.

| Railway. | Section. | Miles. | Date. |
|---|---|---|---|
| City and South London | Bank–Stockwell | 3·2 | 18 Dec., 1890 |
| Waterloo and City . . | .. | 1·6 | 8 Aug., 1898 |
| Central London . . . | Bank–Shepherd's Bush | 5·9 | 30 July, 1900 |
| City and South London | Bank and Moorgate Street and Stockwell–Clapham Common extensions | 1·5 | 1900 |
| City and South London | Moorgate Street–Angel | 1·4 | 17 Nov., 1901 |
| Great Northern and City | .. | 3·5 | 14 Feb., 1904 |
| Bakerloo . . . . . | Baker Street–Elephant and Castle | 3·8 | Mar. and Aug., 1906 |
| Piccadilly . . . . | .. | 9·0 | 15 Dec., 1906 |
| Charing Cross, Euston and Hampstead . . | .. | 8·0 | 22 June, 1907 |
| Piccadilly . . . . | Holborn–Strand | 0·3 | 30 Nov., 1907 |
| Bakerloo . . . . . | Baker Street–Edgware Road | 0·6 | Mar. and June, 1907 |
| City and South London | "Angel"–Euston | 1·3 | 11 May, 1907 |
| Central London . . . | Shepherd's Bush – Wood Lane | 0·6 | 14 May, 1908 |
| Central London . . . | Bank–Liverpool Street | 0·5 | 28 July, 1912 |
| Bakerloo . . . . . | Edgware Road–Paddington | 0·4 | 1 Dec., 1913 |
| Charing Cross, Euston and Hampstead . . | Strand–Embankment | 0·3 | 6 Apr., 1914 |

The only tube railway extension since that date is the section from Paddington to Queen's Park on the Waterloo Railway.

### 2. Electrification and Extension of the London County Council Tramways.

| Year. | Horse. | Electric. | Total Mileage. |
|---|---|---|---|
| 1900 | 72·20 | .. | 72·20 |
| 1901 | 72·57 | .. | 72·57 |
| 1902 | 72·90 | .. | 72·90 |
| 1903 | 88·22 | .. | 88·22 |
| 1904 | 69·48 | 19·25 | 88·73 |
| 1905 | 69·13 | 26·65 | 95·78 |
| 1906 | 73·94 | 30·00 | 103·94 |
| 1907 | 57·96 | 58·88 | 116·84 |
| 1908 | 51·39 | 68·37 | 119·76 |
| 1909 | 42·06 | 85·58 | 127·64 |
| 1910 | 20·03 | 115·50 | 135·53 |
| 1911 | 17·35 | 126·33 | 143·68 |
| 1912 | 13·69 | 132·57 | 146·26 |
| 1913 | 9·60 | 138·81 | 148·81 |
| 1914 | 8·01 | 140·39 | 148·40 |
| 1915 | 5·74 | 144·00 | 149·74 |

Note :—Since 1915 no new lines have been constructed, and the working of the horse tramways has been discontinued.

APPENDIX C—*continued.*

3. Number of Omnibuses Licensed by Metropolitan Police.

| Year. | Horse. | Motor. | Total. |
|---|---|---|---|
| 1900 | 3,681 | 4 | 3,685 |
| 1901 | 3,736 | 10 | 3,746 |
| 1902 | 3,667 | 29 | 3,696 |
| 1903 | 3,623 | 13 | 3,636 |
| 1904 | 3,551 | 31 | 3,582 |
| 1905 | 3,484 | 241 | 3,725 |
| 1906 | 2,964 | 783 | 3,747 |
| 1907 | 2,557 | 1,205 | 3,762 |
| 1908 | 2,155 | 1,133 | 3,286 |
| 1909 | 1,771 | 1,180 | 2,951 |
| 1910 | 1,103 | 1,200 | 2,303 |
| 1911 | 786 | 1,962 | 2,748 |
| 1912 | 376 | 2,908 | 3,284 |
| 1913 | 142 | 3,522 | 3,664 |
| 1914 | 63 | 3,057 | 3,120 |
| 1915 | 36 | 2,761 | 2,797 |
| 1916 | 20 | 2,536 | 2,556 |
| 1917 | 11 | 2,414 | 2,425 |
| 1918 | 7 | 2,277 | 2,284 |

Note.—The reduction in motor omnibuses since 1913 is due to their extensive utilization for war purposes. The number licensed in the current year will approach nearly 3,000.

4. Total Mileage of Roads Covered by Omnibus Routes (London General Omnibus Group Only).

| | |
|---|---|
| June, 1910 | 106 |
| „ 1911 | 131 |
| „ 1912 | 195 |
| „ 1913 | 403 |
| „ 1914 | 521 |
| „ 1915 | 432 |
| „ 1916 | 474 |
| „ 1917 | 460 |
| „ 1918 | 452 |
| „ 1919 | 446 |

Note.—The maximum mileage worked daily occurred in July, 1914, just before the war. The mileage of roads covered at this date was 531.

## Discussion.

The President. The PRESIDENT, in proposing a vote of thanks to the lecturer, said he had not devoted sufficient attention to the subject to enable him to speak of the value of the lecture, and, if he was not mistaken, few of the members could fully grasp the subject of the lecture from hearing it alone. But he felt that it was full of matters of great and pressing interest to the community and worthy of serious study, and he was sure the members would in a very cordial manner express their thanks to the lecturer for his great kindness in placing his views so fully before The Institution that evening. He would ask Sir Maurice Fitzmaurice, who had been so closely in touch with all the problems dealt with in the lecture and had very wide experience in connection with London traffic, to second the vote of thanks.

Sir Maurice Fitzmaurice. Sir MAURICE FITZMAURICE, Past-President, in seconding the vote of thanks, said he thought the lecture would be of very great value, not only to The Institution but to everybody connected with London traffic, because the lecturer was in a position which very few were in, to get hold of valuable statistics. He had known Mr. Gordon for 15 years, during which time he had been persistently dealing with London traffic, and he (Sir Maurice) knew no one who had made such a collection of data and facts relating to it. He thought, however, that there was a good deal in the lecture that required criticism. He proposed to criticize it not from the view of a tramway fanatic, or a tube-railway fanatic, or a motor-bus fanatic, but from the view of one who thought there was plenty of room in London for all the different kinds of traffic. The first thing he wished to say was that the value of the lecture would be very greatly increased if Mr. Gordon would add to it the dates at which tube railways and the different sections of the tramway systems were opened; unless those particulars were added it was impossible to realize the meaning of the statistics for years gone past. He had not intended to discuss the lecture, and the few remarks he had to make would be rather disjointed, taking various points that had struck him. In comparing the surface traffic and tube-railway traffic, the lecturer said: "To relieve surface congestion it is frequently suggested that further passenger transit facilities should be provided underground. Apart from financial considerations, experience in all parts of the world has shown that

the remedy is illusory." He then went on to state: "In 1895, before the Central London Railway was opened, 390 horse omnibuses passed along sections of Oxford Street each hour. In 1903 there was a temporary reduction of 60 vehicles. In 1913, at periods of the day when the Central London Railway is packed to repletion, 517 motor-omnibuses with 70 per cent. more accommodation in total than in 1895 were unable to cope with the demand made upon them"—while the tube railway was full. He could not understand how this latter statement was supposed to prove the contention that tube railways did not relieve surface traffic. It seemed quite clear that if those using the Central London Railway had to be carried on the surface the congestion there would be much worse than existed at present. Then he would like to point out—and he was sure the lecturer would agree—that any suggestions, or proposals, or remarks made by the Royal Commission on London Traffic could have no bearing whatever on the state of London traffic or the position of London traffic at the present time. The Royal Commission was appointed in the year 1903, and it reported in the year 1905, and since that time nearly all the tube railways in London had been opened. The first electric tramway of the London County Council was only started in the year 1903, and when the Report of the Royal Commission was issued in 1905 there were at that time, as far as he knew, only ten motor-omnibuses in the whole of London. The conditions of traffic at that time were so different from what they were now that he thought that the lecturer ought to cut out that reference to the London Traffic Commission. He did not mean to suggest that it had been put in with any intention of leading to wrong conclusions, because he did not think the lecturer had drawn many conclusions from the London Traffic Commission's work, but he still thought that if he would state what had happened since then, and give the dates, it would simplify the views of people reading the lecture, and they would be able to get into their minds the difference between 1905 and 1919. Then there was a small question about flexibility. He quite agreed that flexibility did cause more accidents, but he could hardly agree that accidents should be dealt with as a question of so many passengers and so many tons of goods carried. He thought it would be of very little value to the person who was "accidented" if he knew that there were 10 tons in a vehicle, and it would not make much difference to anyone to know that he had been knocked over by a light motor-car weighing a quarter of a ton. He did not think that method of statistics would be helpful in dealing with London traffic, and it

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would be very difficult to collect such statistics. The question of flexibility was also very important in connection with tramways. He was a firm believer in tramways. One hardly ever read an evening paper without seeing that a large amount of traffic in South London had been held up because a tramcar had stuck on the road owing to some trouble with the plough of the car. A little flexibility there would be a great help, and motor-buses in that way were of great value, because they could pass a motor-bus that had broken down, whereas one tramcar could not pass another. With regard to short streets which were not quite wide enough for tramcars, and which had to be widened so as to get 9 feet 6 inches between the tram-rail and the curb, many widenings had to be done in connection with tramways, which, although small in themselves cost a very large amount of money. Those widenings were not necessary in the case of motor-bus traffic, because of the flexibility of the bus. But he would not like to carry that too far, because in his view there was plenty of work for tramways, in addition to tube railways and motor-buses. He would like to say a few words about tube railways. He might be wrong, but he thought that the lecturer was a little bit "down on" tube railways. It should be considered first of all that tube railways were made in London because London clay was a very favourable material in which to make such railways. Analysing the cost of tube railways, which the lecturer had given at £600,000 a mile—which was about correct, some costing less and others more—it would be found that a large portion of that £600,000 was represented in the cost of the station-tunnels, the stations themselves, and the property required for the stations, and was not spent on the tube railway itself. Roughly speaking, he believed that out of the £600,000 probably £450,000 went to the station-tunnels, the different shafts and passages, and work in connection with the station. If tube railways were made in London again—and he thought they would have to be made—he believed they would be made on quite a different plan from the present system of having stations ½ mile apart. It was quite obvious that the existing tube railways could not take the short-distance traffic and the long-distance traffic as well. In the future he would advise anybody who started to build tube railways to build express tubes which had stations at intervals of 2 or 3 miles; such tubes could easily be built at something like £150,000 a mile. He need hardly point out that it was proposed by the Metropolitan District Railway 15 years ago to build a tube underneath the District Railway from Hammersmith to the City, with only one stop, at Charing Cross. Tubes of that

kind would probably develop very much in the future; they would be made for something like £150,000 a mile; and they would relieve the present tubes, which, as far as he could see, would be always overcrowded at the rush hours. Anybody who watched the District Railway trains going to or coming from Ealing would find that passengers were hanging on to the trains by their eyebrows, whereas if an Ealing train were run from Hammersmith straight to Charing Cross and the City it would not be a great hardship for people who wanted to go to intermediate stations to change at Hammersmith. In that way he thought there would certainly be a new future for tube railways in London. A point about the usefulness of stations, which were ½ mile apart on the existing tubes, was that there were certain places where he would not say tramways could not be provided, but to which they were not brought for certain reasons. For instance, nobody had suggested yet—he did not think he even suggested it himself when he was Engineer to the London County Council—putting a tramway down Piccadilly. It was astonishing to see how many people went very short distances on tubes. One reason was that unfortunately in this country there was a good deal of rain, and it was pleasanter to use a tube railway than wait for an omnibus, because one got under shelter at once, whereas by waiting for an omnibus one would get very wet. That was not a thing which came into the theoretical consideration of such problems, but it was one of the points that certainly gave traffic to tube railways. One thing that was required for the improvement of London traffic had always been wanted, and had never been obtained, and that was, one controlling authority. He was quite indifferent as to who the controlling authority was, so long as it was an authority qualified to deal with, and who would deal with, the matter, and not care a straw about anybody else. If such a controlling authority came into being there would have to be very large extensions of both tube railways, with stations at long distances apart, and the tramway system, and, he hoped, also a very considerable extension of motor-buses. He noticed that in one place the lecturer had said that the motor-bus traffic fell off very much at a certain period, and it would be advisable to give the date of the war among the data he had suggested should be added, because everyone knew that a good many of the motor-buses were then working in France. There was one thing he could never understand about traffic in London, and that was that a very large number of people told him that they wanted to be able to have a seat in a tramcar or tube or bus at the rush hour, and that they thought the fares

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charged were perfectly exorbitant. He was quite certain that seats could not be provided for everyone in the rush hours without charging higher fares, and it was necessary to do either one thing or the other—to run the risk of standing occasionally, or pay a higher fare if seats were provided.

Mr. Gordon.

Mr. GORDON expressed his appreciation of the kindness of the President and of his friend and colleague Sir Maurice Fitzmaurice for moving and seconding the vote of thanks, and thanked the members for having carried the resolution in such a hearty manner. He confessed that when he received the invitation to deliver the lecture he accepted it with fear and trepidation, as he knew the high standard of the Papers which were read at The Institution, and he felt exceedingly doubtful whether he possessed the necessary qualities to enable him to deal with the subject as desired. He was fully aware that he had only scratched the surface of the whole problem. He was glad to have been given the opportunity of delivering the lecture, and if he had helped to stimulate thought—not haphazard thought, but definite thought on certain definite lines—and had helped to make people realize that traffic was a technical and scientific question, he was more than repaid for the work he had done.

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9 December, 1919.

JOHN ALEXANDER BRODIE, Vice-President, in the Chair.

Mr. Ward.

Mr. HENRY WARD congratulated the lecturer on the interesting statistics he had presented and the many valuable deductions he had drawn from them, which would repay the closest study. He would especially direct attention to the Tables. As the lecturer had pointed out, even the most congested streets would permit much more traffic to pass if it were possible to divide the traffic into various lines according to its speed. This, however, was an ideal, and the streets must be taken as they were. Usually the width would not allow more than six lines of traffic—three each way. Of these, that next the curb must be reserved for stopping vehicles; the other two permitted only one line of fast and one line of slow vehicles. On bridges, and at open spaces where there were no buildings, an extra line of vehicles of medium speed could be allowed. As to road-improvements, finance was always the

ruling factor, and therefore the question arose whether it was better to have a number of small improvements or a few large ones; generally, he thought, the latter was the wiser course. Many mistakes had been made in the past. For instance, he remembered the widening of the west end of Fenchurch Street about 1880. Approximately a strip 13 feet wide was added to the roadway, and the remainder—about an equal amount—was sold for recoupment purposes. The City Fathers would give anything now to get that land back, as the traffic was more congested than ever at that point. Later on, Ludgate Hill and Fleet Street were widened to 60 feet. Both of these streets were once more becoming overburdened. He was glad to say that, despite the cost, the Strand was being widened to 80 feet, and that Kingsway, in spite of much opposition, has been made 100 feet wide. Tube railways, he thought, must take but a small part in solving the transit problem. Two great difficulties confronted them, namely, the high capital cost, and the extra working-expenses and delay due to the necessity of using lifts. If Sir Maurice Fitzmaurice's tentative suggestion were adopted and fewer stations were constructed—say one every 2 miles instead of every ½ mile—public convenience would not be adequately met. Lifts used considerable power and led to much loss of time at each end of a short journey. Sir Benjamin Baker, in a series of articles in "Engineering" many years ago, laid down an ideal system of planning underground railways. Stations were to be placed at ½-mile intervals at the top of comparatively steep inclines. The trains would rapidly accelerate in running down the hill, storing up energy and requiring a minimum of brake-power when approaching the next station uphill. Incidentally, the further advantage would accrue that it would bring the stations near the surface. This ideal had not been adopted to any material extent even in deep tube railways, owing to practical difficulties. He could speak with some knowledge, as he had been joint engineer with the late Mr. J. H. Greathead, M. Inst. C.E., for schemes for certain tube railways which Parliament had been unwise enough to throw out. With regard to "rush" hours and peak loads, one-quarter or one-third of the London County Council cars were returned to the sheds during the middle of the day. The difficulty of the peak load became overwhelming in war time at the Arsenal, where over 100,000 men were employed. It was relieved to a considerable extent by the authorities arranging that work should be stopped at various times, namely, at 4.30, 5.0, and 5.30 p.m. As to the improvements in trams and omnibuses, the motor-bus had been much improved; its weight, now 4 tons, used to be 6 tons.

Mr. Ward.

Mr. Ward. In this respect the tramcar compared unfavourably with the motor-bus; it weighed 15 tons, and although it carried 2½ times as many passengers, there was much room for improvement. The first tramcars had not covered tops, and the addition of these added nearly 1 ton to the weight. Later on, powerful magnetic brakes were fitted, and these put such severe strains on a somewhat top-heavy vehicle that the cars had to be strengthened. No new cars have been built for several years with the exception of trailers, but he had no doubt that it would be possible to save much weight in fresh designs using special metals and, perhaps, diagonal bracing. The cost of the conduit system at pre-war prices was about £19,000 per mile, as against £10,000 for the overhead system. Private companies would not willingly pay the extra cost, but he thought the London County Council was fully justified in doing so on æsthetic grounds. There was plenty of room for both tramways and omnibuses; each he believed to be best in its own sphere; but he thought that in narrow streets and congested areas the omnibus had the advantage; elsewhere the tram had the best of it, especially if buses were used to feed them. In the matter of accidents there was not much difference between the omnibuses and trams. It was true there were fewer accidents with tramcars, but, as Mr. Gordon suggested, this might be due to omnibuses working in more crowded thoroughfares. At the same time, he thought it was partly due to the flexibility of the omnibus. Everybody knew where the tram was going, but, as an old motorist, he always feared the vagaries of the omnibus-driver. Flexibility was not an unmixed blessing. In comfort the omnibus failed. In tramcars the passengers on top were sheltered in bad weather, and there was decidedly more room per passenger on the tramcar than in the omnibus. London tramcars were what might be called "public utility" vehicles. Privately owned concerns must earn a profit. A municipal tramway, in his view, should not necessarily do this; its fares should be adjusted so that it only just paid its way. The cream of the traffic in London was in the City and West End, where the omnibus had the monopoly and where the fares were higher. The tramway had to do the spade work in the outer and poorer districts. The rush-hour traffic was non-paying, and therefore was left almost entirely to the tramcar. The tramways alone provided cheap workmen's fares—at a loss of about £70,000 a year. This tended to ameliorate the housing difficulty, and so might be a real saving to the public in the long run. The earnings of the tramways had to be sufficient not only to pay interest on the capital, but also to pay off nearly 4 per cent. of the capital—

about £420,000—every year. Anything short of this would be called a "loss." A company did not pay off its capital, and it could reduce its dividend without being said to make a loss. Ample depreciation must be provided in both cases. With regard to road repairs, all repairs and renewals of the rails should, of course, be paid for by the tramways; but why should they have to maintain the central 17 feet width of the road? They did not use it, and, indeed, the more the rival omnibus and general traffic wore it out, the more the tramways had to pay to keep it in repair. It was not unfair in the old days of horse-drawn tramcars, as then the horses by always putting their feet in the same spot or same line did cause an unusual amount of wear of the paving. It was estimated that this cost the tramways £180,000 per annum—a heavy handicap. Approximately the rates paid on track to date equalled £1,000,000 and the capital paid off equalled £5,000,000 out of £13,000,000. Mr. Ward.

The Right Hon. JOHN BURNS remarked that he was one of three who, 20 years ago, went to America and Europe in order to see what form of traction, other than railways, would be most suitable for the extraordinary demands which London's increasing traffic was making. After exhaustive inquiry, he had not the least hesitation in saying that, in case it was decided to supplement the railway train systems with other forms of locomotion, and if it was decided to adopt tramways as an auxiliary, on all grounds the choice of the conduit system, as against the overhead system, was quite justified. He thought the trial of the conduit system in London had been amply justified. From an æsthetic point of view it was best. It was possible, he thought, for the engineer to combine strength with artistic design and comfort. Indeed, it was his business to co-operate with all concerned, in order to do all that was possible for the appearance of the city. From that point of view the conduit system had justified itself. At the same time, the ideal system in London would be a single public ownership of both omnibus and tramways. He hoped public opinion would move in that direction, so that cheapness and rapidity might be secured without accident. He knew every important city in the world, and although Londoners sometimes indulged in self-depreciation, he knew of no city of comparable size in which locomotion was as good as in London. That was saying a good deal in face of the density of its traffic during the busy times of the day. Londoners were making increasing use of their enhanced privileges. There was a great decrease in drunkenness, and with increasing sobriety the people developed an inclination to get out into the fresh air; the increased wages and The Right Hon. John Burns.

The Right Hon. John Burns.

shorter hours had enabled them to do this. All that meant that people were brought more into the streets, and there was more and more traffic to and from the City. Who would think it possible that there were no less than 80,000 foreigners brought into London from the country daily? And London's traffic difficulties would increase; further demands would be made on all concerned. It was the duty of engineers, then, given the necessary financial backing, to find a plan to make travelling easier, with less crushing, to make crooked roads straight, and rough places smooth. He believed the financial difficulty could be surmounted, but he did not propose to go into that on this occasion. It appeared that Mr. Ward confirmed Mr. Gordon's assertion that tramways were cheaper per mile run, much safer for public and passengers, and more convenient, carrying 2 millions per day, mostly of the working class. The omnibus, for which flexibility among other things was claimed, was used more by the "butterfly" shopping class. From the point of view of the class of people which the tramways carried—the essentially industrial population—the tramways deserved well, securing as they did the rapid transit of the workers in the districts in which they were installed. He was well acquainted with the action of the Home Office and Scotland Yard, and also the Report of the Royal Commission on London Traffic, but there was one thing, he thought, which had been overlooked. Much of the difficulty in London was not due to the causes generally supposed, but rather to the fact that the engineers had been starved of opportunities of showing their skill in tunnelling and in building more bridges over the Thames in places where they were very much required. He would scrap all the suspension bridges spanning the Thames from Kingston to the Tower Bridge. A strong heavy bridge should be built at Hammersmith, similar to, but even better than London Bridge or Waterloo Bridge. Putney Bridge needed widening without delay. Wandsworth Bridge was clamouring for destruction. Several other bridges on the river were much too narrow, and Chelsea Bridge was totally inadequate to carry the traffic which should go over it. In short, what was urgently wanted appeared to him to be the doing away with suspension bridges, and the erection of more and better bridges to carry the enormous north to-south traffic. He would withal have beautiful as well as strong bridges, which would improve the appearance of London. Whilst he advocated new bridges connecting north and south London, he would add that the inhabitants could not much longer tolerate the conservation of the two square miles of Hyde Park and Kensington Gardens, and of other areas occupying much of the district from

Piccadilly Circus to Hampstead, and right up to Willesden, for the sole benefit of motor-cars, omnibuses, and taxi-cabs; and there must be tunnels and surface roadways from north and south, traversing Hyde Park. With the exception of Vauxhall (which the drivers called the "Dardanelles," as they could never get through) nearly all the congested portions of London were where tramways did not go at all. Those portions of the metropolis had to be brought into any scheme for the relief of London's congested traffic, and the sooner, he thought, the better. There was at Trafalgar Square one of many examples. The refuges provided there in ridiculous profusion necessitated the employment of many policemen who might otherwise be usefully employed elsewhere. These refuges caused great inconvenience and were much too numerous to be useful. Surely the authorities might make wise use of the street which existed. He could never make out why King Charles's statue was allowed to remain at so inappropriate a point of a busy traffic centre like Charing Cross—just at the spot where it should not be. In any event, if nothing better could be suggested, his view was that the statue should be removed about 60 feet westward. He had, of course, only touched the fringe of the subject, and it went without saying that, beyond the engineering and financial questions, there were many other things which contributed to the solution. Time forbade his taking them up on that occasion. He complimented Mr. Gordon on his Lecture, which he had read with interest. The Right Hon. John Burns.

Colonel R. E. B. Crompton, C.B., said that as Sir Maurice Fitzmaurice had dealt with the railway question, it would be convenient to consider the lecture from the point of view of the road engineer rather than from that of the London County Council Administration, to which the previous speakers had addressed themselves. They had to thank the lecturer for giving them a very complete essay on a subject which was of such complexity and difficulty that it demanded the study of a life-time. He himself had gone into the subject of the occupation of road-surfaces by various classes of traffic when he prepared his address to the Engineering Section of the British Association at Glasgow about 16 years ago, and he had then attempted to deal with the most important part of the present Paper, namely, the carrying capacity of the streets with the means of locomotion that were then available. At that time tramcars had been perfected and were much as they were now; motor-omnibuses had only just been started, but their possibilities were evident. He had then made a large number of observations on traffic at congested points in London, and had found that at Knightsbridge, near the French Embassy, there was Col. Crompton.

Col. Crompton. a point at which the traffic intensity, expressed in tonnage per yard width of available roadway, was a maximum, and he believed still continued to be at a maximum not exceeded at any point in London, New York, Paris, Chicago, or any other large city. He would refer to that matter later, as it was of importance, when he called attention to the formula for street surface occupation on page 7 of the lecture, on which Mr. Gordon's calculations for Table II appeared to be based. But before coming to the vexed question of tramways versus motor-omnibuses, he wished to say that he was in complete agreement with Mr. Gordon on the following points, which were of extreme importance. Those were, first, the necessity of a traffic authority to draw up regulations which would enable the existing streets to carry a maximum of traffic, which was only another phrase for minimizing the congestion. On that he thought there could be no difference of opinion. He agreed with the lecturer that the congestion due to slow-moving traffic could only be got over by the slow-moving traffic being separated from the fast. It must be relegated, during certain hours, to alternative lines of thoroughfare. He also agreed that congestion and the limitation of point-to-point speed when the slow-moving traffic had been got rid of would still continue as far as certain level crossings were concerned, and he thought that the lecturer's suggestions for "gyratory" crossings (*Figs. 4* and *5*) were well worth a trial, which would not be costly. He also agreed that the occupation of the streets by standing vehicles was a scandal, and ought to be reduced to the minimum by strict regulations. With passenger vehicles that could be accomplished by agreeing on fixed stopping-places for omnibuses; with goods vehicles, by insisting that the standing of vehicles in front of warehouses and railway receiving-offices should be completely done away with by those offices providing spaces for their vehicles within their premises, so that when vehicles were loaded and unloaded they did not stand out in the streets. He also agreed with the lecturer that the number of underground and overhead means of crossing for foot-passengers should be increased, and perhaps their use should be made compulsory, or at least passengers crossing on the surface at those points should do so at their own risk. Before coming to the points on which he differed from the lecturer, he wished to say a few words on the great and recent change which had taken place in London passenger-traffic. Partly owing to the war, to the want of delivery by tradesmen of goods required for ordinary household purposes, and no doubt partly due also to the comfort and speed of the motor-omnibus services, the travelling

habit of the ladies of the household had increased to such an extent that the old crush hours of cityward and homeward traffic were no longer restricted to certain times of the day as regarded the motor-omnibuses and underground services, so far as those services were for short distances: the crush existed throughout the whole working-day. That travelling habit was likely to continue, and had now to be dealt with. He did not know whether it existed as much on the south side of the river as he knew it did on the north side. All the shopping streets on the north side of the Thames had to deal with that special traffic, and it was of the greatest importance to consider whether it could best be dealt with by motor-omnibus or by tramcar. He now came to the lecturer's conclusions on street occupation by vehicles, based on his formula on p. 7. As far as he could see, V in that formula was, or ought to be, the maximum speed reached by the vehicle between stops. That V differed widely from the average point-to-point speed, including the traffic stops, acceleration and deceleration, and other stops caused by other traffic. That reduced point-to-point speed it would be convenient to call V′. In the case of long runs and infrequent short stops the difference between V and V′ might be small, that was to say, V′ might be as high as 60 per cent. of V; but in the case of heavy vehicles with frequent stops for taking up and setting down, and those due to traffic delays, V′ was most frequently only about 40 per cent. of V. That figure, in the case of the London tramcars, was the result of many observations he had made on the trams on the south side of the river. It meant that a tramcar which could attain a maximum of 16 miles per hour had, as a rule, a V′ speed of 6·5 miles per hour; whereas the lighter motor-omnibus, which was equally capable of 16 miles per hour, did in many cases make a point-to-point speed (or V′) of 10·5 miles per hour. Therefore, in making a comparison between the street occupation of different classes of vehicles, the possible headway of those vehicles must be calculated using the formula V, and afterwards the number of cars or vehicles per minute must be diminished by the difference between V and V′ for the particular class of vehicle used. That might range from 40 per cent. in the case of the heavy London County Council tramcars to possibly 80 per cent. in the case of the very light motor-cars or motor-cycles and side-cars which were now becoming so common. It appeared, therefore, that the want of that correction in the lecturer's formula accounted for his belief that there was still a place in the London streets for the huge cars of the London County Council; and in that connection it must be remembered that when the lecturer compared the use of

Col. Crompton.

Col. Crompton. trams in London with that in other cities, other cities as a rule used far smaller and lighter cars; and there was ample reason for their doing so, because of the time saved in loading and unloading passengers from the cars. Sixteen years ago, when he read his Paper before the British Association, the observations he then made in company with the late Sir John Macdonald all over London, and particularly on the east-and-west routes from Piccadilly to Hammersmith, and from the City through Oxford Street, showed that even at that time, when horse-omnibuses constituted the majority of the omnibuses on the road, the flexible horse omnibus was a very efficient means of moving large quantities of passengers at a fair rate and with a minimum of congestion. For convenience, he would hereafter use the word "headway," which was an American expression, to denote the time in seconds between the passage of each omnibus past a given point on any route, and he had prepared the following figures in regard to the present headway of motor-omnibuses, which had been supplied to him by the London General Omnibus Company, and which showed that at the present time the number of passengers transported on an important route such as Piccadilly were 11,400 passengers per hour going westward and the same number carried in the reverse direction. When the new pattern of omnibus, which occupied the same space in the roadway, took the place of the present B type, this number would be increased to 13,400 per hour, every passenger having a seat. From these figures it was shown that a crowd in the streets eastward of Piccadilly could be carried westward by a double line of the new buses, and if the present slow-moving traffic were at that time forced to take a different route the crowd could be transported at the rate of 22,400 per hour, without Piccadilly being congested more than it was at present under ordinary traffic conditions. He contended that no form of railway or tramway service could transport an equal number of passengers. That was entirely apart from the second question, namely, the congestion caused by the inflexibility of the tramway service itself, which, quite apart from its carrying-capacity, was perhaps one of the greatest arguments against the extension of the existing tramways. He had observed that in the south of London the tramways passed through neighbourhoods where a great proportion of the tradesmen's deliveries were carried out by hand carts or by bicycles or tricycles. Anyone who drove another vehicle had his speed limited by that of the hand cart or bicycle immediately in front of him, as he was unable to overtake it and pass it in the narrow space which for long distances existed between the curb and the near side of the

tramcars. The delays caused to traffic by its being unable to overtake on the near side of the tramcars was a potent cause of delay and congestion; yet the lecturer did not call attention to it, and he had therefore brought it forward as prominently as he could. Mr. Ward had stated that in many respects the tramcar was a more comfortable vehicle than the omnibus, chiefly on account of its roof affording protection against the weather. He could not admit that. He thought anyone who observed the unstable appearance of the double-decked London County Council tramcar, subjected to side winds when crossing bridges or at other exposed points, must admit that they were not an engineering job. It was surprising that so few accidents had occurred. That difficulty was accentuated with narrow-guage tramways. He would be the last to advocate that the motor-omnibus, which was quite as stable against side winds as the tramcar, should be provided with a roof cover. Londoners were a hardy race; in most cases they preferred to travel outside to get a view of the streets, and they were undoubtedly right in doing so. Col. Crompton.

Sir ALEXANDER GIBB thought Mr. Gordon was to be heartily thanked for having brought the subject of London traffic forward at the present time, when it had got into a state which everybody agreed must be improved. London traffic did not concern only Londoners; it concerned the whole British Empire. To use a commercial term, London might be looked upon as the "Head Office" of the British Empire, and the various provincial towns as Branch Offices; and the more efficient London traffic was, the more efficient would be the carrying on of the work of the State in every way. There was no doubt that everybody would have to help to solve the problem. It was not going to be solved solely by tramways, or by omnibuses, or by trains, or by new roads and bridges, but it would be solved by a combination of all these; and it would have to be realized that no good would be done without the help and sympathy of the general public. Some small advantages that certain people possessed now would have to be given up for the good of the common cause. To his mind, there was no Society or Institution in London which could do more to solve the problem of London traffic than The Institution of Civil Engineers. After all, the problem was in the end an engineering one, and provided, as Mr. John Burns had said, that the money was forthcoming, the problem seemed to be capable of practical solution. He regretted that Mr. Burns had not told them a little more clearly where the money was to come from, but he seemed to be very confident that it would come from somewhere. All the money could not Sir Alexander Gibb.

Sir Alexander Gibb.

come from the ratepayers; it would have to come from a good many sources; but a large amount of money would be required, and people would have to face that. The problem could well be divided into two sections; one the immediate alleviation of the trouble, and the other its permanent alleviation. The first, as no doubt many of the members were aware, had already been started and was now going on; and any suggestions for that alleviation—things that could be done forthwith by mutual consent—would be very heartily welcomed by the Technical Committee on London Traffic—of which Mr. Gordon was a member. The second part of the problem—the permanent alleviation of the trouble—required very much more mature consideration; but it was being gone into very thoroughly, and use was being made of the evidence and conclusions of all the many Committees and Societies which had dealt with the subject of London traffic. He did not quite agree with Sir Maurice Fitzmaurice that the work of the 1905 Commission was now useless. Its findings would certainly have to be brought up to date, but there were many excellent points in them. Human nature had not changed, although many other things had. In conclusion he would like to emphasize the importance of everybody helping. The problem of London traffic was one which could not be solved by a Committee, but which had to be solved by the British public, the public of London, and largely by the brains of the members of The Institution of Civil Engineers.

Mr. Thomson.

Mr. H. Lyon Thomson remarked that he might be a somewhat ungrateful person, but his only excuse was that he represented a large class of ungrateful persons, because there were very few people with whom his daily public life brought him into contact who seemed to be at all overwhelmed with gratitude for the gifts which the London County Council proposed to shower on them in the form of trams. They were quite happy without them. He thought there was no municipality in London more dependent on the inflow of passengers than was Westminster. It was to the interest of Westminster to bring in and take out as many people as possible; but, having once got them into Westminster, it was important to allow them to carry on their business there, and the advent of tramways would paralyze the great industries and the great commerce of Westminster. Without wishing to take up the time of the meeting unduly, he would like to point out that the proposed tramway scheme would strangle every main artery out of Westminster. To start with, they were caught at their eastern outlet, Ludgate Circus. At their southern outlet they were met by the tramcars coming up Victoria Street. There

would be more trams at Hyde Park Corner, their western outlet. Mr. Thomson
At the north-western outlet at Marble Arch they would be met by trams. The only escape would be towards the north, and, when coming down Oxford Street and proceeding eastward, the traffic would be cut by the trams at Tottenham Court Road, and all that remained would be the gap in the proposed line coming down Tottenham Court Road to the National Gallery. If that line succeeded in getting down to the National Gallery, nothing would prevent it from extending down Northumberland Avenue and joining the trams on the Embankment. He was one of the few on the Westminster Council who supported trams along the Embankment, and as to minor details he had an open mind. He did not attach much importance to the question of dead ends, because at Blackfriars, which was no longer a dead end, one could see as much shunting of cars as at any dead end in London. There was a saying which had been much used lately to the effect that England must be made a place for heroes to live in. If he might paraphrase that saying and bring it up to date, he would say that the London County Council were endeavouring to make London a place to live out of.

Mr. Gordon, in replying, remarked that he was very grateful Mr. Gordon.
to those gentlemen who had discussed his lecture; they had treated him with far greater kindness than he had anticipated. He had, however, one small complaint to make. The object of his lecture had not been to make a special study of the relative merits of tramways and omnibuses; he had attempted to deal more or less with the general question of London traffic. It was no doubt exceedingly irksome that at the present time the London County Council, in a fit of greater or less insanity, was proposing to introduce tramways in inconvenient streets; but that, after all, was not a matter which appertained particularly to his Paper. It was a question which would have to be fought out elsewhere, and he was rather sorry the discussion had not been concentrated more on the scientific aspects of the problem. There were other large cities in the world which were circumscribed by a network of tramways, a worse fate than that which threatened Westminster, and in those cities, to his personal knowledge, great traffic was being carried on, and great enterprises carried out, and greater industrial and social advancement was being achieved. Therefore he proposed to deal with the more or less technical criticisms which had been made, mainly by Sir Maurice Fitzmaurice and Colonel Crompton, on one or two items in his lecture. Sir Maurice Fitzmaurice had suggested that it would be valuable if

Mr Gordon. a Table were added to the Appendix showing the dates at which the various traffic instruments in London were inaugurated, and he hoped to append a statement to that effect when the lecture was reprinted.[1] Sir Maurice thought that the figures he had given as to the relative growth of underground and surface transit did not entirely bear out the statement made in the Paper that underground traffic does not relieve surface congestion, and he said: "What would London streets have been like if there had been no tubes?" He fully agreed, but the congestion in the streets of London had not been reduced one iota since the construction of the tubes. It might very well be true that increasing traffic made demands for the utilization of more than one instrument of transport, but the growth of traffic in large urban centres went on at such a rapid rate, and so increased with an increase in the supply of means of locomotion, that it remained true that no underground system of transit in London had helped to reduce surface congestion. When the Central London Railway was opened, about 1900, more passengers were carried than was the case 2 years ago, but on the other hand the amount of traffic on the surface of the streets had increased enormously. He still ventured to think that to rely on underground traction to relieve surface congestion would be relying on a broken reed. He agreed with Sir Alexander Gibb that the Report of the Traffic Commission, which sat in 1903, was certainly not a "back number." Although changes had taken place in certain particulars, the verities of engineering remained the same, and the Report of the Commission on London Traffic contained a great many of them and would always be of paramount interest. Sir Maurice thought that the suggestion he had made that the number of street accidents should be related to the useful work done was not very helpful to a person who had been injured in one of those accidents. That was quite true. From the point of view of a person who had been injured in a street accident it was of relatively small importance how many other passengers might have been carried safely; but if one wanted to compare the incidence of street accidents, one had to reduce them to a common denominator. No other common denominator that Sir Maurice could suggest was of any greater value—most of them were of less value—than the one which he had suggested. Assuming that a certain work had to be done—and two or three different instruments of traction could be employed, each of which necesitated running a different mileage to achieve its object—if it

[1] See Appendix C, p. 52.—Sec. Inst. C.E.

were assumed that the number of accidents caused by those various instruments of transit differed, it was no use relating those accidents to the number of miles run; the common denominator in all those things was the useful work done. For example, if a million passengers had been carried, it did not matter, so far as the number of accidents was concerned, whether 7,000 miles or 30,000 miles had been run in order to do so: that did not affect the useful work done. He agreed largely with Sir Maurice on the question of the future design of the London tubes. They must serve as instruments of high-speed locomotion, with stations at long intervals, leaving the short-distance journeys to surface traction. He was glad to know that the cost of such tubes would be very much less than the cost of the tubes which had been constructed hitherto. Tubes of the present type ought to be continued out of London as surface railways along the great trunk railways. All those means of locomotion in London would have to be correlated, and, as Mr. John Burns had said, they must be brought under unified ownership if the best results were to be achieved from the organization as a whole. Colonel Crompton did not altogether agree with him about tramways; but, apart from that, he was very glad to find that Colonel Crompton apparently thought that many of the suggestions made in the Paper were worthy of consideration. Colonel Crompton thought the type of crossing suggested might be worth trying, and Mr. Gordon certainly hoped it would be tried. They agreed that a great deal more could be done in the way of traffic regulation, so as to increase the carrying-capacity of the highways. He hoped that that was being done in London at the present time by Sir Alexander Gibb's Committee. He looked to all those methods to secure improvements, but he had to confess that the growth of London traffic was so rapid that the time had now come when great schemes of new roads were required for the development of London traffic. Not only roads, but instruments to use those roads were required. The part which was played by vehicles in relation to roads was apt to be forgotten. A vehicle increased the carrying-capacity of a highway. During the recent railway strike the highways were largely occupied by people walking to the centres of work from districts comparatively near to them. Far larger numbers of people could be carried along a highway than could walk along it; the development of roads must be accompanied by the development of vehicles to travel on them. He did not agree with his friend Mr. Ward that tramways were invariably cheaper than omnibuses. Sometimes they were, and sometimes they were not. As shown in the Tables of his lecture,

Mr. Gordon.

Mr. Gordon. where there was a comparatively slight volume of traffic with a low-load diversity it was madness to put tramways down, but on the other hand it was equally mad to use omnibuses where tramway loads were obtainable. More traffic regulation was wanted in London, and a better co-ordinated system of traffic; greater development of roads, greater co-ordination between roads and vehicles, and the utilization of all instruments of traffic in London to the best advantage, for the sake of the common good of the whole community.

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*** The following contributions to the discussion were communicated in writing.—Sec. Inst. C.E.

Mr. Hurse. Mr. A. E. Hurse observed that it was not possible to compare London with any other large city owing to its intense density of traffic and its very haphazard lay out. The rectangular type so noticeable in the more modern city, possessed enormous advantages. It had been noticed that traffic tended to flow parallel to the main watercourses, and therefore such roads or streets should be the wider. That was unfortunately not followed in the modern city of Adelaide. In passing from the rectangular type, it might be noticed that no congestion of traffic was very noticeable in New York, excepting at the junction of Broadway and Fifth Avenue, and in the older parts of the city.

With regard to London, the very dense traffic was greatly impeded by the converging lines at certain points—and these were not improved in such cases as Trafalgar Square and Piccadilly Circus by the fact that they were on sloping ground, and also by the narrow approaches in some cases, such as the West Strand. Subways should be more numerous, and refuges should be better placed. It seemed to be a foregone conclusion that the Cenotaph in Whitehall was to remain in its present position, and notwithstanding sentimental feelings, it was to be regretted, as monuments and statues were best out of the centres of thoroughfares of dense traffic. One would like to see, from the traffic point of view, the removal of such obstacles as the Temple Bar monument, and the statue of King Charles I. It might be hoped that some day soon the property on the west side of Whitehall between the Admiralty Old Buildings and the new Approach from the Mall would be set back and the pavement lowered, and that the West Strand might be widened from Villiers Street corner to the junction of Northumberland Avenue. It might be suggested that the Grand Hotel

be treated as the Ritz Hotel by the pavement passing under the building; that the steps of St. Martin's Church be removed in front, the approaches being at the ends, the front steps being replaced by a retaining-wall treated in harmony with the church, architecturally. Mr. Hurse.

Piccadilly Circus presented a difficult problem, as nowhere was the pavement wide enough to allow of subway approaches, and these could only be made by setting back some existing property in each case.

Parliament Square could be much improved by joining up the square to the east end of Great George Street, so as to continue the east road line of Parliament Street south to St. Margaret's Church, and bring the Victoria vehicular traffic in front of the House of Commons. Another improvement would be to conduct the motor-bus traffic to and from Vauxhall along Palace Yard and Grosvenor Road instead of by Great Smith Street and Marsham Street. Should it prove possible to overcome the opposition to trams across Hyde Park, there was no reason why they should not pass along Birdcage Walk and Great George Street, the pavement of which latter on the north side might be reduced in width, a new road being cut from Victoria in line with Vauxhall Bridge Road into Buckingham Palace Road.

The Bank impasse presented considerable difficulties, but they might be considerably relieved by structural alterations—an expensive undertaking.

No one had foreseen what proportions traffic had and was likely further to attain, and no modern street excepting perhaps Kingsway, Northumberland Avenue, Parliament Street and the Embankment had been made wide enough.

Were there alternative roads, the density of vehicular traffic would not be insurmountable, and provided those roads were broad enough, tramways would not be a serious obstacle to other traffic. It was safe to say that most people preferred to use a motor-omnibus in place of a tramcar where there was an option. To see a mile of tramcars waiting for large works to turn their hands out, and then being hung up for a considerable time because of a breakdown in one of the leading tramcars afforded clear proof of their disadvantages. Buses could go where tramcars could not, and could pass up side streets when there was a block. Naturally, if there were alternative routes and wider roads, tramcars could deal with passenger traffic, provided there were not too many stops en route, more advantageously than motor-buses.

Should tramways be allowed in London and Westminster, there remained the question whether the London County Council would

Mr. Hurse. be satisfied if they were restricted to running tramcars there, only up to 9.30 a.m. and after 5.0 p.m. so as to deal with the work-a-day traffic. This suggestion was made as a partial solution of the difficulty, and would require to be considered from the financial side.

The speeding-up of the tube railways by cutting out some of the stations at hours of heavy traffic was worthy of consideration. The connections of the different tubes adjoining stations required immediate improvement, either by moving staircases or more numerous lifts. The construction of more tubes was a matter of money, and though no one cared for State interference, the traffic problem of London was of such a nature that State assistance could be better justified than in most other cases.

A central authority seemed to be inevitable, and for that there were precedents in the Metropolitan Water Board and the Port of London Authority. Perhaps it would be possible to make it an extended Corporation of London by combining the London County Council with it. That would obviate the Government department system as much as possible.

Some of the main railway-line stations were antiquated: London Bridge, South Eastern, was particularly so; and Euston needed to be brought out to Euston Road, as suggested some years ago but prohibited by Parliament.

Mr. Spensley. Mr. J. Calvert Spensley noticed that in Mr. Gordon's lecture reference was made to the planning of the tube railways and the disadvantages arising from requiring passengers to traverse long tortuous passages and ascend and descend stairs. The principal reason for this arrangement was, of course, that the tubes ran under the roadway while the stations and lifts were necessarily on private land at the side of the road, or even in side streets. There would seem, however, to be no good reason why every tube station should not have been planned with a central platform and with lifts carrying passengers from the street level direct to the platform level, the lifts in the case of exchange stations halting at the platform level of the upper railway. This planning would have been possible if the tubes had been diverted from beneath the roadway to beneath the station. Preferably, perhaps, the suggestion made on behalf of the London County Council in evidence before the Joint Committee on Electric and Cable Railways, 1892, might have been adopted, namely, that main traffic centres should be selected and the tubes be driven in straight lines the shortest (and cheapest) way between them. The only serious difficulty would have been the possible cost of running under private property; but the Committee of 1892 recommended that the companies should be allowed

to acquire a way-leave instead of purchasing the freehold of any private property under which they might pass; and as the recognized standard of payment was only £1 a yard, the cost would have been very small in comparison with the total cost of a tube railway, amounting to £650,000 a mile. Moreover, the additional cost would probably have been more than saved in the cost of construction by the shortening of the routes and the elimination of passages, apart from the saving in working-expenses and the value of the improved facilities in inducing and in handling traffic. The fact that the present planning was done deliberately made it the more important that careful reconsideration should be given to the subject before any new tubes or extensions were constructed. Mr. Spensley.

Reference was also made in the lecture to frontagers utilizing streets widened at enormous cost for standing vehicles. The most notable instance of this probably occurred in the Strand. Apart from a proportion of the net cost of the Aldwych and Kingsway improvement (£774,000), the cost of widening the Strand at Holywell Street was £500,000. In connection with the latter, the principle of an improvement charge was adopted, but property owners on the south side of the Strand were exempted. Since the improvement one of these frontagers for long periods of the day had occupied an area of some 1,000 square feet of the widened Strand for the loading and unloading of vans across the foot pavement—a user which would have been impossible before the improvement when the carriage-way of the Strand was only 27 feet wide. In 1910 a case was brought to the High Court by the Westminster City Council to restrain the defendants from unreasonable user of the highway, but it was held that the user was not "unreasonable"—that the position of the defendants' premises was peculiar, as there was a very unusual width of street in front of them, and that having regard to the nature of the traffic it was not impeded by the presence of the defendants' vans (*The Times*, 10th May, 1910). It was interesting to see how the swerve of the traffic to avoid the standing vans was marked by the wear of the roadway, showing clearly that the westward traffic in this 60-foot carriage-way was in practice reduced to a single line of vehicles.

Mr. W. A. Tait welcomed Mr. Gordon's Lecture on account of the information and challenges it contained. Mr. Tait.

One of the main troubles in regard to the conduct of traffic in London was due:—

(*a*) To the great number of separate railway companies, and

(*b*) To the still greater number of railway termini which were not properly linked up to one another.

Mr. Tait. During the war it was a regular occurrence to see troops from the north, who were going on foreign service, detraining at King's Cross, etc., and marching across London to entrain again for a Channel port. That showed very clearly that there was no proper linking up. No doubt there was linking up of a sort between pairs of termini; but, not only did this linking up fail to provide for the minimum of changes between trains and stations, but it was not of such a form as to enable free interchange of the rolling stock of different companies.

It was quite simple for a passenger with little luggage to get from some station served by the South-Eastern Railway, e.g., Dover, via Charing Cross and the Hampstead Tube to Euston; but, on arrival there, he would find that, under present-day regulations, he was not permitted to use the trains which ran between Euston and Edinburgh. In order, therefore, to get from Dover to Edinburgh by rail and tube he would, on arrival at Charing Cross, go down a staircase before he entered the Hampstead Tube lift and travel by the Hampstead Tube train to Piccadilly Circus, where he would again change to another tube train to King's Cross.

Alternatively, the passenger from Dover might prefer to walk practically the whole length of Charing Cross Station, i.e., outside that station to Charing Cross (Embankment) Station on the Underground, and wait there for an "Inner Circle" train to take him by a circuitous route to King's Cross (Underground) where, after ascending a fixed staircase, he would have about 150 yards to walk through a subway to the entrance to King's Cross (Great Northern) Station.

It was, perhaps, not surprising that railways did not penetrate London, having regard to—

(1) The cost involved in fighting in Parliament and in constructing the line, and the exactions made by various Local Authorities;

(2) The various Parliamentary and Departmental obstacles.

There was, of course, little inducement for a railway company to construct lines at great cost through London if their enterprise was to be rewarded by the application and enforcement of various cheap-train Acts. Probably it would have been better if Parliament had long ago offered some little encouragement in the shape of a special mileage, as, for instance, in the case of the Forth Bridge, for which a mileage, notwithstanding its length, of 19 might be claimed by the owning company. It was unfortunate that the opportunity had not been taken to make proper connecting lines between certain pairs

of the more important termini when prices of construction were enormously lower than they are at present. There could be no doubt that such inter-terminal lines would have very materially facilitated the handling of such passenger and light-parcel traffic as had a reasonable right to go through London. Many suburban passengers using Waterloo to-day would have been grateful for an inter-terminal line which would have brought forward sufficient of the much-needed rolling stock at the right time. Mr. Tait.

There did not appear to be any justification for making the inter-terminal lines through London, especially the City of London, sufficient in number to carry heavy goods and mineral traffic, which could perfectly well be sent outside London. One drawback in designing inter-terminal lines was that no two railway companies seemed to have the same minimum structure gauge. An inter-terminal line, to be of any real use, would require to have at least four lines of way, and, having regard to the weather conditions in London, it would, no doubt, be better to widen the 6-foot way to at least 8 feet, to permit of the erection of signals in places where they could not possibly be mistaken by engine-drivers.

Before passing from the question of inter-terminal lines, it might be pointed out that the existing facilities for interchange, even at adjoining stations, were in many respects very unsatisfactory, e.g., the old Gower Street Station on the Metropolitan was of very little use for interchanging traffic with Euston at present. There ought to be an extension either of the underground station (now called "Euston Square") or else a proper subway between it and Euston Station of the London and North Western Railway. King's Cross Underground Station was a particularly bad example of permitting incoming and outgoing passengers to use the same staircase during rush hours. There did not appear to be any subway between Cannon Street and the Bank Stations. The Bank station was a very good example of how not to do it, because passengers leaving the lift had to fight their way out against passengers coming in, and other sets of passengers also met in the narrow tortuous passages to which the lecturer had referred.

The Central London and Piccadilly tubes crossed at Holborn. Museum Station on the Central London, and Holborn on the Piccadilly tube, were recognized exchange stations, but in order that a passenger might get from one to the other he must *inter alia* go up one lift and down another and walk 150 yards on the surface and make at least two crossings of busy thoroughfares.

It seemed to Mr. Tait very remarkable that this practice should obtain, seeing that special attention had been drawn to the low

Mr. Tait. running-costs of the tubes. It was obvious that a very little addition to the running-costs would effect better discipline among the users of the tubes, which would bring about very considerable modification of the present-day congestion.

Reference having been made to discipline, it seemed reasonable to offer a criticism upon the design of the rolling stock in the underground railways and tubes. No proper system appeared to be adopted in any of the tubes, or even the underground railways, for separate entrances and exits from the carriages. A rather better condition of things obtained in the Glasgow District Subway, where passengers had always been trained to enter a carriage by one door and to leave by another.

The London County Council had initiated one good instance of disciplining some of their passengers, i.e., the users, during rush hours, of the single-deck tramway cars, which ran between Westminster Bridge and Holborn. A car coming along the Embankment towards Westminster Bridge discharged its passengers from the driver's end of the car near Westminster Bridge. Simultaneously, a fresh lot of passengers was entering at the tail end of the car, and, the moment that sufficient passengers had entered to fill the car, it was started in the opposite direction, when it immediately took the proper line of rails for the Aldwych Subway. One little drawback arose in respect that, during the time the car was emptying and filling, some half-dozen or more cars might be held up immediately behind it. That, however, was a matter capable of easy remedy by the provision of a loop or siding with a proper island. It was obvious that the best use was made of the earning-capacity of the particular car referred to. A car, like a train, earned money when in motion.

Arising out of the last point, one naturally turned to the time taken to get passengers on and off an omnibus or tramcar by means of the narrow platform at the back of a bus, or of a tramway car. Every ordinary tramway car had a stairway down the front, and there seemed little reason why it should not be remodelled and used so that passengers, from the top at any rate, when alighting, would not be getting in the way of other passengers who were ascending to the upper storey. The present staircase in front of a tramway car did not appear to obstruct the driver's view, and there did not seem any reason, therefore, why a properly arranged staircase should not be fitted at the front of a bus to enable upper deck passengers to alight without interfering with ascending passengers. One possible objection, however, was that with separate accesses and egresses, some passengers might occasionally make their escape

without paying their fares; but with properly-arranged staircases and better platforms, both omnibuses and trams would spend more of their time in motion than in standing still. The average speed of the trams and buses would thus be increased, and there would probably be less need to develop power in rapidly accelerating the trams and buses as at present. Mr. Tait.

The above remarks applied with even greater force to tube trains. The expression "passengers off the car first, please," was in itself a frank confession that the design of the tube cars was capable of considerable improvement, and it might be pointed out that the present overcrowding of the tube trains was a rather short-sighted policy, because the last individual fighting his way into a tube train, not only delayed the starting of that train, but contributed to the delaying of following trains.

Reverting to tramways for a moment, considerable improvement was no doubt brought about by the adoption of trailer cars during "rush" hours, but it was surprising to observe that chains were stretched across the leading end of the platform in a way to prevent passengers from alighting on the footpath at the front end, and that hampered the loading and despatch of the tramway trailer car; though it must be observed that the platform at the end of the leading car was also open to considerable objection as at present arranged.

Tube railways possessed a special advantage over the old Underground railways in respect that, in general, they had island platforms. It was for consideration whether, during "rush" hours, occasional non-stop trains might be provided so as to pass three or even four consecutive stations. One result might be that a few passengers for intermediate stations might be carried past their intended destination, but those few passengers could quite easily cross the island platform and go back by a train travelling in the other direction; and it might be noted that, westward of Piccadilly at any rate, the rush hours do not occur in both directions at the same time.

It was understood to be the intention of the authorities to reconstruct the City and South London Railway, and that raised a point worthy of consideration. However desirable it might be to reconstruct the tube so as to let in carriages of reasonable size, it seemed even more desirable to reconstruct the stations so as to form a model for future construction or reconstruction. It might very well be that the reconstruction of the City and South London Railway stations would bring about the provision of an additional platform, so that, even without altering many of the

Mr. Tait. carriages now in use, passengers might get out on one side when other passengers were entering at the other side.

The lecturer mentioned that "in the central area of London it is found uneconomical to employ motor delivery vans. The carrying capacity of the highway has been and remains taxed to the uttermost." So far as the City and its immediate surroundings were concerned, the highways were no doubt taxed to the uttermost owing to the fact that only from 3 per cent. to 8 per cent. of the vehicles were motor driven. This might be compared with the West End, where nearly 100 per cent. of the traffic was motor driven, and the lecturer very properly alluded to this point when he said:—"In 1902 there were 15,000 vehicles proceeding east and west in 12 hours, in 1914 there were 25,000. North and south traffic had increased in similar proportions. If the original conditions had continued to exist traffic would long ago have been blocked. In 1902 all traffic was animal driven, in 1914, 83 per cent. was power driven. Power of rapid acceleration and deceleration has reduced the crossing time and provided greater capacity. This feature has saved the situation."

Arising out of that, it might be asked why should not the authorities restrict the use of certain vehicles during certain hours, and particularly during rush hours? There seemed no reason why the use of horse-vehicles should not be limited during rush hours and should not be prohibited during any hours in bad weather. There were many hills in the City which rendered a reserve of power desirable, and that was a very good reason for forbidding the use of donkey-carts and single-horse vehicles. A reasonable period of time would, of course, have to be allowed to owners to bring about the change, and it might be considered whether or not the Post Office should not specially undertake the collection of small parcels of a very much higher maximum size than at present, from the City and its immediate surroundings. A service properly worked by the Post Office would probably serve the same purpose as a clearing house and bring about an enormous reduction in the number of vehicles using the City streets.

For many years past four-wheeled horse-cabs were not permitted to go through Piccadilly Circus. There seemed no reason why well-considered regulations should not be made as to the use of City streets. In any case the horse's length took up considerable useful space.

The surface highways in and near the City being pretty fully occupied, every effort should be made to divert, as far as reasonably possible, the traffic to underground routes; but the lecturer did not

appear to realize the desirability of making the best use of the money already spent on the construction of tubes, and evidently despaired of further use being made of them, when he used such words as these regarding the tube railways :— Mr. Tait.

"Tube railways are constructed with stations ½ mile apart in the hope of enabling effective competition with surface traction to be carried on. They have failed in this purpose. For distances up to 2 miles, the overwhelming bulk of surface traction, they are generally slower and less convenient. Their lay-out is on no comprehensive, definitely preconceived plan. There exists in consequence between the various lines at what are called interchange stations an enormous transfer of passengers carried out by traversing long tortuous passages and ascending and descending stairs."

The proper course to adopt was, as already indicated, to try to improve the facilities for the use of the tubes. Many of the tortuous passages referred to by the lecturer might be quite unnecessary, and great improvements might be carried out at comparatively small cost, particularly where there were interchanges from one tube or railway system to another. Everything in fact should be done to encourage passengers to use the railway for short runs, particularly as the fares for these short distances were relatively more remunerative than those for longer distances.

From many points of view it was desirable that there should be unity of control of the various systems, i.e. tube railways, tramways, omnibuses, etc., and it might be pointed out that omnibuses at present apparently escaped taxation, and their owners, therefore, were living upon other people, including the owners of the tube railways and tramways with which they competed. A great deal of damage was undoubtedly done by motor-omnibuses, but it was not the owners of the motor-omnibuses who paid for the whole of the damage.

There were many instances of incomplete highways where steps ought immediately to be taken. For instance, Cromwell Road ended practically nowhere at present, and ought to be extended westward across the railways. The late Sir John Wolfe Barry called the attention of the authorities to the desirability of making a proper road from the corner of Victoria Street and Tothill Street in a nearly northerly direction, through St. James's Park to the Duke of York steps, at the time the Central Buildings were being erected, but that opportunity was missed.

The Aldwych subway was a most useful link and completely disproved the statement so frequently made in the Committee rooms that there was little north and south passenger traffic through

Mr. Tait. London. In present circumstances, however, the subway emerged too soon at its northern end, with the result that tramway cars obstructed traffic from Southampton Row, Theobald's Road, etc. Improvements at the Theobald's Road end of the subway would justify an addition to the rails on Thames Embankment.

Mr. Gordon. Mr. GORDON, in reply to Mr. Hurse, observed that the provision of subways or viaducts to obviate surface crossings in the Metropolis was rendered exceedingly difficult by the enormous capital expenditure entailed. It was not merely a question of carrying one road over or under another. Provision must be made for diverging traffic and this added enormously to the cost by making the re-planning of a far larger area of generally immensely valuable property almost inevitable. Subways for pedestrians, except as means of reaching station premises, had not been conspicuously successful in London. At the Mansion House probably less than 10 per cent. of foot-passengers thought it worth while to go down and up the stairs to avoid one of the busiest traffic crossings in the world. The method of working traffic employed by the police largely obviated the necessity of pedestrian subways.

Mr. Hurse called attention to the difficulty under which all rail-bound traffic laboured in so far as delay to one vehicle affected all following. That no doubt was true. It was easy, however, to exaggerate the importance of this feature. In actual practice it was found in the Metropolis in 1918 that each motor omnibus ran 37,500 miles and carried 363,000 passengers. Each tramcar, despite its rail-bound character, ran 39,000 miles and carried at a far higher load diversity, 515,000 passengers.

Mr. Hurse, Mr. Spensly and Mr. Tait all agreed with the lecturer in his condemnation of the existing facilities for interchange of traffic on Metropolitan railways. Change of vehicle in itself inflicted a burden on the traveller, and the success of surface traction in competition with railways was largely due to the accentuation of these difficulties. To speak of Charing Cross and King's Cross Stations being linked up either by the tubes or the Inner Circle Railway was to give a clear example of how not to do it.

In respect of the design of station-platforms and rolling stock employed by railways, tramways and omnibuses, Mr. Gordon agreed with Mr. Tait in thinking that there was need of more consideration. It was a sad commentary on past efforts that at "rush" hours, when the need for accommodation was greatest, the speed, owing mainly to station delays and to difficulties of loading and unloading was lowest. No doubt "disciplining passengers," to which Mr. Tait alluded, by the formation of queues, etc., was of service. It seemed, however,

to the lecturer to be fundamentally wrong, that in cases, as on tube railways, where it was a question of saving seconds, loading and unloading should proceed successively instead of concurrently. Mr Gordon.

Mr. Gordon entirely disagreed with Mr. Tait as regarded the use of railways by short-distance passengers. In ordinary trunk railway working it was clearly recognized that it was the "long distance haul" which was remunerative. Railways were pre-eminently the instruments of bulk traffic. With large short-distance traffic, changing at every station, the speed became so low, that the justification for the large capital expenditure entailed disappeared. Tube railways should not merely duplicate surface transit. They should provide facilities which the latter were unable to supply.

Some of the specific street improvements urged by Mr. Hurse and Mr. Tait were already receiving the attention of the Technical Committee on London Traffic, on which the lecturer was serving. He would bring their other proposals before that Committee so that they should receive due consideration.

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